CANADA
DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
WILLIAM MCINNES, DIRECTING GEOLOGIST.

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No. 93, GEOLOGICAL SERIES

Investigations in the Gas and Oil Fields of Alberta, Saskatchewan, and Manitoba

BY

D. B. Dowling, S. E. Slipper, and F. H. McLearn

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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The Dakota gas horizon. Diagram built up from subsurface contours shown on sketch map No. 1779.

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THE STRUCTURE AND CORRELATION OF THE FORMATIONS UNDERLYING ALBERTA, SASKATCHEWAN, AND MANITOBA.

By

D. B. Dowling.

PART I.

The Structure and Correlation of the Formations Underlying Alberta, Saskatchewan, and Manitoba.

INTRODUCTION.

Power, or fuel to produce it, has always been necessary for the upbuilding of great manufacturing industries and in late years has become necessary also to the industries connected with the production of food. By the introduction of internal combustion engines and the rapid development of their use in transportation and traction as a substitute for animal power, the tilling of large areas on the plains has been made possible without a corresponding increase of man-power. The increase in the use of these engines in agriculture and for war purposes has made great demands on the store of light oils and has made the search for new oil fields a matter of national importance. The presence of natural gas in Alberta led to the exploration of that field for oil reserves and numerous exploratory wells were drilled. Unfortunately, many of these were located on badly selected sites; but a few were so placed that they have demonstrated large extensions to the known gas fields of the plains.

In the early history of the plains little value was attached to the presence of gas unless it was so situated that it could be piped to centres of large population to be used as fuel to replace coal; but the importance of these gas reserves and, therefore, of the areas in which they may be found is now constantly increasing as new ways are discovered of utilizing the gas at the wells.

HISTORY.

Natural gas was accidentally discovered more than twenty years ago in a well drilled for water at Alderson (Langevin) on the Canadian Pacific railway and another well was bored at Cassils; but the flow at these wells was not important. Small seepages of gas in the bed of the Saskatchewan river led to the putting down of shallow wells near Medicine Hat and in the report of the Geological Survey for 1900 it is stated that the gas from two wells with a pressure of 115 pounds was being used for lime-burning.[1] These wells were comparatively shallow, with small flows. Deeper drilling was undertaken and a better supply of gas was obtained at a depth of 1,000 feet. By 1904 there were six wells producing gas and the industrial development of the town began. Two wells were bored at Langham and three at Edmonton about 1905, but these proved unproductive. Wells in which a little gas was found were also bored at Calgary. Greater success attended boring on the anticline south of Langevin and Cassils, where the Bow Island well gave an enormous flow. This well was com-

[1]Geol. Surv. Can., Ann. Rept. vol. XIII, p. 98S.

pleted in the latter part of 1908 and interest was again aroused in the Calgary field, but the Geological Survey advised against drilling at the city, recommending rather that the western edge of the syncline be tried. The next well, unfortunately, was not located near the edge of the syncline, but very near Calgary, and was unsuccessful. In 1913, an anticline was located at the western edge of the syncline, on the south branch of Sheep creek, and in accordance with advice previously given, wells were bored on it by Calgary interests. Oil of high grade was struck over the small area which constitutes the present Sheep Creek oil field.

The oil boom of 1914 will long be remembered on account of the indiscriminate locating of oil leases without reference to the structure of the underlying rocks and the consequent very large useless expenditure in drilling. The general absence of favourable structure areas in the disturbed belt of the foothills has directed attention to the plains, where the formations are only gently folded, and a little oil has been obtained in the Peace and Athabaska valleys and the presence of gas proved at various places. A more extended study of the general structure, than has yet been made, is necessary before the extent of the new fields can be predicted.

GENERAL GEOLOGY.

In the general geological study of this very large area, dependence has had to be placed very largely on information gained from the beds outcropping at the surface; and existing geological maps have been prepared with the view, mainly, of showing the possibilities of the occurrence of coal within reach of the ordinary mining operations. It is true that, from careful observation of the attitude of the beds at the surface, the attitude of the beds beneath can be inferred, since a great thickness of apparently quite conformable strata underlies the plains; but, as perfectly evenly deposited beds are rare, variations in thickness must be looked for and the only absolute check on the thickness must be got from drilling records. Consequently the aid of the drillers was sought, who, although at first reluctant to furnish the information, have now come to realize the benefit that follows the collection and correlation of these records and are more readily responding. Although the records contain details of a large number of wells, the deep wells are too few to permit of deductions being made with certainty in regard to the structure of the lower horizons.

FORM OF BASIN.

The beds underlying the plains have, broadly, the form of a very large basin; that is, a bed which outcrops along the edge of the plateau to the east and is found also in the foothills to the west, will be found at various depths beneath the surface between these points. In this basin, in Canada, there seem to be two very low points or depressions which are separated by a slight upraise. It is assumed that these depressions still contain original sea water that has not been expelled by the pressure exerted by the load above and that, therefore, they constitute areas of little value for gas or oil accumulation.

Illustrations of the results of the preliminary study of the structure or form of the basin are given in the maps and figures accompanying this memoir. The general outline is shown on sketch map No. 1780 and details

of the Canadian area on sketch maps Nos. 1775 to 1781. Attention is called to Plate I which is introduced for the purpose of showing to the non-technical student the meaning of the term *structure contours*. These contours are theoretical lines showing the form that the surface of the layer or bed under discussion would exhibit if the overlying material were removed.

POROUS BEDS.

The necessity for a study of the structure contours of the various porous beds arises from the commonly accepted theory that where these beds have not become solidified by infiltrating solutions, gas will seek the higher parts and oil, if present, will be found above the water saturation line. Borings have demonstrated that there is almost a certainty of finding salt water in several beds in the lower parts of the basin. In the higher parts, where gas might be looked for, it is important to know whether or not the structure, or attitude, of the beds is favourable for the retention of the gas. An arch or dome structure is preferred, or, in cases where the beds outcrop, the sealing of the upper part by surface water must be assured. Although many beds of sand occur in the deposits filling the basin it has been found that oil accumulations are to be looked for in the lower beds only, although occasionally asphalt lenses occur in beds high up in the section. They are reported to occur, for example, in the Edmonton series at Pigeon lake, Egg lake, and Nakamun. It is not thought probable that they have originated from an upward seepage of oil from below.

An examination of the general distribution of the porous beds shows that in the foothills they contain an abundance of coarse, fragmentary material. Under the plains the amount of sandy material is much less and in the sections studied in Manitoba the rocks are mainly composed of fine silt. This variation in the composition of the beds may be taken as an indication that the material was largely derived from a source west of the plains and, as a large part of the finer material was sea deposit, it would indicate also that the land area which supplied the coarse-grained material was considerably elevated and suffered rapid erosion. Another conclusion which has been previously discussed[1] is that the fluctuations of the sea-level caused several forward or eastward advances of the shore-line when the land areas of British Columbia spread into Alberta, previous to the general retreat of the sea.

In the north the lower sands appear to thicken toward the north and may possibly have derived their materials from a different source.

The formations in the basin, that contain sandy measures, include the Tertiary deposits in the Alberta syncline, as found in the quarries at Calgary. The beds at Edmonton, though mostly clays, have, associated with the included coal seams, beds of sand; and small flows of gas have been found in shallow wells at various places, underlain by the Edmonton deposits. The top of the Belly River formation is frequently sandy and beds near the base may also be considered as possible gas retainers. The sands exposed in Milk river, though thinning out rapidly to the east, are the containers for the gas at Medicine Hat. The great gas accumulation

[1] The Cretaceous sea in Alberta. Trans. Royal Soc. Can., vol. IX, 1915, p. 27.

is, however, to be found in sandy beds included in the lower part of the Colorado group. These beds are just above the horizon assigned to the Dakota formation which here is not well marked. Sands below the Dakota, which rest on shales of Jurassic age in southern Alberta and on Devonian limestones in the north, are impregnated with heavy oil; and in the foothills, in areas that have been subjected to much disturbance, with a much lighter oil.

GAS HORIZONS.

TOP OF THE BELLY RIVER SERIES (SKETCH MAP NO. 1775).

The area underlain by the possible gas horizon at the top of the Belly river is limited and to the south is divided into two parts by the Bow Island anticline. The beds dip away from the outcrop and would seem to afford very meagre opportunities for the accumulation of gas. Small flows obtained at Castor and Tofield would seem to indicate that the outcrop was sealed by surface water.

TOP OF LOWER PIERRE SHALE (SKETCH MAP NO. 1776).

The value of this horizon as a gas sand is not very great, though at Medicine Hat there are small flows from the shallow wells that were first put down, At Cassils and Castor also, small flows are obtained. The bed serves an important purpose, however, as a horizon-marker in deep drilling operations, for, over a large part of the plains, the beds beneath consist of a continuous series of shales which extend with little change in character from 1,300 to 1,800 feet before sands are again encountered. The sand beds above this series of shales are not everywhere well marked, but in many places they may be distinguished by their general light colour in contrast with the dark colour of the shales beneath. This horizon-marker in the south is represented by the lower part of the Foremost beds. In central Alberta it is represented by the base of the Ribstone Creek formation, exposed on Battle river and on the Saskatchewan at Brosseau. Farther north this is probably about the horizon of the base of the Wapiti River sandstones. In southern Alberta there is in the Bow Island anticline a still lower sand which may be used as a marker.

DEPTH TO LOWER PIERRE (SKETCH MAP NO. 1777).

As the top of the lower Pierre may be used as a marker, its approximate depth below the surface is shown on sketch map No. 1777. This is dependent on the surface elevation indicated in sketch map No. 1774.

MEDICINE HAT GAS HORIZON (SKETCH MAP NO. 1778).

No attempt has been made to map in this place any large extent of these gas-bearing beds, since they have not been recognized definitely to the north of the Bow Island anticline. The thinning of the beds to the east and their flooding on the upper part of the anticline has been described in Geological Survey Memoir No. 93 under the discussion of the Milk River sandstones. The water in this case is fresh, but carries a little carbonate of soda acquired from the sands.

GAS HORIZONS NEAR BASE OF COLORADO GROUP (SKETCH MAP NO. 1779).

Difficulty was experienced in constructing a map to show the attitude of the beds holding the great gas flows, for it was found that the beds are not continuous. The irregular plane assumed is approximately that which separates the Colorado shale from the Dakota sandstones. In the eastern part the underlying bed is a sandstone; in Saskatchewan it is made up of sandy shales or sands; and in Alberta it is probably variegated green and red, sandy shales. In the latter district the gas sands will be found overlying the horizon mapped and in the east, beneath it. It will be noted that a much larger area is here represented as being underlain by the gas sands and a rather comprehensive view will be had, from the diagram given on sketch map No. 1780, of the form of the Cretaceous basin.

Saturation of the beds by saline water may be expected at various elevations, but the level of saturation is generally somewhat above sea-level and it will be readily seen that large areas can at once be eliminated from the category of possible gas and oil beds on this account. Of those remaining the greatest gas pressure and flow have been obtained from the uprise at Bow Island. Along the northeastern upward slope (sketch map No. 1779) the tendency is for gas to escape by way of the outcrop unless local folds are present to retain it. The most favourable structure in this region is a flattened anticline or terrace starting in Saskatchewan and reaching Peace river at Peace River town. Along the southwestern edge of this structural terrace, eight gas wells have already been proved at Viking and a smaller flow of gas was obtained in a well at Athabaska. These flows are from sands near the Dakota horizon, that is, from about the horizon of the top of the Grand Rapids sandstone. North and east of Athabaska the proximity of the outcrop and the upward inclination of the beds reduce their value as possible gas producers.

OIL AND GAS SAND AT BASE OF CRETACEOUS (SKETCH MAP NO. 1781).

From the records of a few deep wells in which oil-saturated sands are recorded it is deduced that these sands occur below the gas horizon represented in sketch map No. 1779. In the foothills some of the oil occurs in the Blairmore formation (of Dakota age approximately) and more in rocks probably of Lower Cretaceous age. On the southern plains the oil sands are confined to the basal beds of the Cretaceous. Natural outcrops of oil sands in the Athabaska valley are now reported by Mr. McLearn, page 27, to be of earlier age than the Dakota. From these observations it would seem that the oil horizon is practically the same from north to south in Alberta.

The eastward extension of these beds is at present unknown and it would seem profitable to establish its limit, but the area in which this exploration might be carried on is difficult of access at the present time.

Between the Athabaska and Peace rivers, the oil sands are replaced by shales north of or near north latitude 54 degrees, so that migration of oil would be arrested or directed up the beds toward the Athabaska. It would seem, therefore, that the largest area in northern Alberta with possibilities for the discovery of oil is that indicated on this diagram.

A comparison of diagrams Nos. 1779 and 1781 shows that there is, t the north, a great thickening of the beds lying between the two horizon

mapped and the foothills show thicker beds in that direction also. The increase in the thickness of the beds from southern Alberta to Athabaska amounts to about 500 feet and to Peace River it amounts to an additional 200 feet. This increase in thickness is largely made up of sand beds and in the area where the elevation of these beds is well above sea-level, gas accumulations are frequent in the beds above the oil-soaked sands which still are found to be the lower ones. Beyond the foothills or disturbed belt, all the oil discovered is of a heavy specific gravity—comparable to that in the McMurray tar sands.

DEPTHS FROM SURFACE TO TOP OF OIL SAND (SKETCH MAP NO. 1782).

As in diagram No. 1777, the indications given on this diagram are dependent on the surface elevation as given in sketch map No. 1774, and consequently are approximate, but may serve as some indication of the depths to which it will be necessary to drill to reach the oil-bearing sands.

GAS AND OIL FIELDS.

The fields that have been studied in some detail include the foothills area, the Bow Island anticline, and the Central Plains terrace on the eastern side of the basin, in the vicinity of Battle river.

THE FOOTHILLS.

The western part of the Alberta syncline descends, probably, to great depths, and, as beds comparatively low in the section appear in the foothills, their upward slope is comparatively steep. If even a heavy oil were present in the bottom of the basin, the very heavy pressures and higher temperatures due to depth should be favourable to its distillation or alteration and as the short limb of the anticline offers least frictional resistance to its migration, and an increased impulse through steep slope, leaks of gas or oil might be looked for at the outcrops if they were not concealed by overthrust faults. In the area southwest of Calgary selected for testing for gas the edge of the western limb of the syncline is overturned in anticlinal form and the beds, therefore, form a natural reservoir. This fold seems also to have acted as a condensing chamber, and the oil there found bears no resemblance to crude oil but is generally considered as a condensation product. It contains about 60 per cent gasoline and that found in the higher strata has a much higher specific gravity.

The main obstacle in the way of finding other fields along this margin is the broken nature of the structure. The edge of the syncline is rarely bent over into arch form and is generally broken by faults; moreover, the beds are concealed by a heavy covering of overthrust strata, making the physical difficulty very great in reaching the productive measures.

BOW ISLAND ANTICLINE.

The lower measures of the Bow Island anticline are exposed in the upthrust of the Sweetgrass hills in Montana; but the area exposed is not large and the vent that would be afforded by their outcrop seems to have been sealed by dykes radiating from and surrounding the central masses.

Wells at the boundary line have proved the presence of very thick oil and some gas. Wells farther north show great gas flows and sands impregnated with heavy oil that resembles an asphalt. The wells supplying Calgary are near the saturation line of the gas sands and may be considered to mark approximately the northern end of the field. The gas in that area is found in sands that appear to be in the Benton. The sands at the top of these shales outcrop in the valley of Milk river and provide artesian water over a wide area. The saturation of these beds with water from Milk river prevents the escape of the gas in the outer rim of the structure, where it forms the supply obtained in the first wells at Langevin and Cassils, and in those now used at Medicine Hat.

CENTRAL PLAINS TERRACE.

Wells in Manitoba and Saskatchewan have demonstrated the presence under those provinces of shales from which gas and probably oil could have been derived, but so far have not shown the presence of sands in close proximity to these shales. It is improbable, therefore, that any large gas or oil fields underlie this part of the plains. The western and northern portions may have possibilities, but development and search should not be undertaken until the better chances of the western part of the plains have been fully tested. In the study of the structure a terrace has been found to extend along the northeastern edge of the part of the basin that approaches sea-level. At Peace river the lower sands are above sea-level and at Battle river somewhat lower. The slope may not be uniform along the length of the terrace, and irregularities in it may in certain localities take the form of anticlines and provide containers favourable for the accumulation of oil or gas. The same irregular form may be repeated in the higher slopes toward the outcrop on the Athabaska, so that the McMurray sands, known generally as the tar sands, which contain heavy oil at McMurray, may elsewhere provide oil, as seems to be the case at Peace River. At this latter place the upward escape of the oil along the beds is prevented by the replacement of the sands to the north by shales. Though good flows of gas may possibly be got over a very wide area, the oil obtained, so far as is known, has proved to be very thick and heavy.

CORRELATION OF BEDS BY DRILL RECORDS.

Records compiled from drillers' logs of wells situated at fifty-two localities in Manitoba, Saskatchewan, and Alberta, are given in the appendix. The locations of the wells numbered in a general east-west order, may be found on the relief map, No. 1774. A comparison of the details of the records of wells is useful where the wells are close together, but where wide areas separate them, details are of small moment and only the larger distinctions representing formations can be recognized. The observer is much aided in this study by a visual representation of the thicknesses in seeking the probable division lines. Plottings have, therefore, been prepared of a number of the sections and an attempt has been made at a correlation. A careful study has shown that although the observations recorded by the drillers are wanting in many respects, sufficient information can be gleaned from them for a very general comparison.

There is in the series a general indication that three broad series of beds are penetrated; an upper, coarse-grained, sandy series, a very thick series of shales, and a lower sandy series. The shale series is present in most of the records and as there is no single bed that can be easily distinguished throughout the basin the correlation has been made largely upon the recognition of the top of the Colorado shales, though it is admitted that this division is not easily recognized in the well records from the eastern part or in the exposures of the north.

WEST-EAST CORRELATION (FIGURE 1).

A selection of wells to give a west-east correlation will be found in Figure 1. The correlation of the western wells is much simplified by the presence in each of the Milk River sandstone marking the top of the Colorado shales. Farther east the division line is less certain owing to the fact that specimens from the critical part of the section are wanting in the cores that were kept of the Moosejaw well. With the arrangement adopted it will be seen that there is evidence of a change in the amount of deposition of the various formations. The marine series representing the Montana group thins materially to the west and the marine shales of the Colorado thicken and show inclusions of sandy beds in the same direction. The coarse-grained or sandy members, both in the lower formations and in those above the shales of the Colorado, decrease in thickness toward the east.

The sandy beds above the Colorado shale and those beneath the Bearpaw unite in the foothills and form what has been called the Belly River formation. To the east the formation is divided into several members by marine shales and the lower sand probably disappears. The remaining sandy members have been traced easterly nearly to the Elbow of the Saskatchewan. The grey, sandy clays found in the Moosejaw well section may represent a southeasterly extension of some of these beds, though the portion associated with this formation, shown on the diagram between depths of 500 and 1,000 feet, may represent mostly marine deposition with sands occurring at the top and bottom only.

There is a possibility that the dark sand found in the Deloraine well at 160 feet may represent the sand found in the Moosejaw well at 900 feet and if this is true it would seem to indicate that the Pierre shales of Manitoba, the Odanah and Millwood, may both be lower Pierre. Beneath the shale series an undivided sandstone member appears in the eastern sections. In the Etzikom well and also from records of wells in the foothills variegated red, green, and grey-blue shales and sands appear. The study of the foothill exposures has established the correlation of the top of these variegated beds with the top of the sand of the eastern section. A great thickening of this lower series is, therefore, evident.

The same well sections are shown in Figure 2 in natural order, that is, the elevations of the surface at the well sites are plotted approximately in their relative positions in reference to sea-level; and from it the position of any part of the section above or below sea-level can be ascertained.

SOUTH-NORTH CORRELATION (FIGURE 3).

The surface exposures and their correlation give a much more definite basis for the arrangement here made. In the south the Milk River sandstone is a very definite horizon-marker. Farther north, to about the latitude of the Victoria well, the base of the Foremost beds serves as a horizon-marker. In the northern sections a heavy sandstone series beneath the Colorado shales is well marked. The arrangement of the sections suggests that the Montana shales on Athabaska river belong to the lower Pierre.

The same series plotted to their proper relative elevations are shown in Figure 4. This is the same treatment as Figure 2 of the west-east series.

PART II.

SKETCH OF THE GEOLOGY OF SOUTHERN AND CENTRAL ALBERTA.

By

S. E. Slipper.

69963—2½

PART II.

Sketch of the Geology of Southern and Central Alberta.

INTRODUCTION.

Alberta may be divided into four major structure provinces extending as belts northward from the United States boundary. The most westerly of these divisions is the Rocky mountains. Eastward are the foothills, or the disturbed belt, separated from the Rocky mountains by a profound escarpment. The foothills or disturbed belt is succeeded by the large Alberta synclinal basin. East of this again to the south is the low, broad arch of the Bow Island anticline extending to the Cypress hills which are formed of the easterly dipping beds of the prairie uplift. In the north the syncline is followed by the central prairie terrace.

In detail the rocks of the foothills are greatly folded and faulted, exposing rocks of the early Cretaceous sedimentation. The Belly River beds are generally the highest strata preserved. They are found in the troughs of the folds and on the downthrow sides of the faults.

As the strata dip under the Porcupine Hills syncline, the structural displacements seen in the foothills give place to a gentle eastward inclination and the Belly River formation disappears under the succeeding Bearpaw, Edmonton, and Paskapoo formations, or in the south under the St. Mary River formation, Willow Creek beds, and Porcupine Hill beds.

On the eastern flank of the syncline most of the beds above the Bearpaw and Belly River formations are eroded away and the remaining Belly River and older rocks are upwarped in the south into a broad low anticline which is referred to as the Bow Island anticline and in the north into the central plains terrace.

SOUTHERN ALBERTA.

HISTORICAL GEOLOGY.

During the Mesozoic era a very unstable area of erosion existed west of the present Rocky mountains and within this region and to the east of the mountains was an area of deposition which was occupied for the greater part of that time by a shallow sea. The shore-line of this sea made several alternating advances and retreats toward and away from the western continent, these movements depending upon uplifts and subsidences of the land. The resulting sedimentation was an alternating stratigraphic system of marine and deltaic or continental deposits which, in section, have the appearance of interlocking wedge-shaped formations with the deltaic deposits decreasing in thickness eastward and the marine formations "wedging out" westward.

In the area under discussion no Triassic sediments have been discovered except in the western part and principally in the Rockies. The Jurassic seas are represented by the Fernie formation. The main deposition took place over a wide area but the thickest sections are found west of the summit of the present Rocky mountains. In the mountains and eastward the deposits represent still-water conditions.

Early Cretaceous times are represented in the area by detritus accumulated on land, in rivers, and in small lakes, or possibly by sediments deposited by short, shallow incursions of the sea and by the vegetable accumulations of broad marshy flats. These form the strata of the Kootenay formation and the Blairmore or Dakota formation. There is some possibility that the Kootenay is the low shore-line phase of the retreating Jurassic sea, whereas the earlier Blairmore represents the succeeding interior accumulations, and the upper Blairmore the shore deposits of the sudden and rapid advance of the Colorado seas.

The Upper Cretaceous is divided into two epochs, Colorado and Montana, indicated by two advances and retreats of the sea on the interior of the continent.

In the region of the foothills, the period of the last incursion of the sea, the Montana, was, almost entirely, one of uplift, hence there was very little chance for the sea to encroach far westward and the western sediments are mainly deltaic and shore deposits representing the Belly River formation.

During the deposition of the Edmonton formation the Cretaceous sea was making its final retreat from the continent.

At the close of the Cretaceous the interior basin remained above sea-level and formed an area of continental deposition during early Tertiary time. The greater thicknesses of the Tertiary sediments are now found in the basin of the Alberta syncline, but these sediments no doubt extended far over the plains, as they are found on the Cypress hills and in southern Saskatchewan.

The synclinal basin of the Porcupine Hills area and the anticline of the prairie were formed during late Tertiary times by tangential compression from the west. Other deformations were probably caused by the igneous intrusions of the Sweetgrass hills, Montana.

STRATIGRAPHY.

All exposed beds belong to the Cretaceous and Tertiary systems.

TERTIARY.

Paskapoo Formation.

This formation is one of some irregularity due to the manner of deposition of the sediments. These appear to be mainly deltaic deposits of the many streams from the west.

The sandstones of the Paskapoo are mostly massive, cross-bedded, or irregularly bedded strata of lenticular form. Many unimportant local unconformities occur. The colours are light grey or yellowish grey and the component grains are coarse with ferruginous or calcareous cement.

Interbedded with the sandstones are dark green and black sandy clays. The formation as a whole has a light yellowish appearance in extensive exposures.

A measured section gave a thickness of 3,000 feet, but owing to the irregularity of deposition, measurements of thickness of strata are not very dependable.

Porcupine Hills Beds.

These are essentially the same series as the Paskapoo, but include the upper Tertiary beds occurring in the Porcupine hills.

Willow Creek Beds.

These beds underlie the Porcupine Hills beds in the extreme southern exposures and are characterized by sandstones and clays having a reddish or purplish tint. The combined thickness of the Porcupine Hills beds and the Willow Creek beds is given by G. M. Dawson as 3,000 feet.

CRETACEOUS.

Edmonton Formation.

Underlying the Paskapoo are about 1,300 feet of beds in which dark grey and green, sandy clays predominate. Interleaved with the clays are beds of hard, greenish grey sandstones. In exposures the formation has a dark earthy appearance, is soft, and is easily eroded.

The Edmonton in its lower beds at least, represents the brackish water phase of the retreating Pierre sea. The fossils are a brackish water type: *Ostrea, Corbula, Corbicula,* etc., being common forms; freshwater types are found in the upper strata.

St. Mary River Beds.

The St. Mary River beds in the Porcupine hills and farther south represent or are the equivalent of the Edmonton formation.

Bearpaw Formation.

The strata are bluish black clay shales containing concretionary ironstone nodules and lenses; thin, sandy, shale layers are common. Marine forms characteristic of the Upper Montana sea are of frequent occurrence. In the foothills in the northern part of southern Alberta, the marine phase is practically non-existent; thin beds of unfossiliferous shale are occasionally found which may be correlated with the Bearpaw, but usually the Edmonton rests upon the Belly River. Southward the formation thickens rapidly in the foothills and equals the depth of shale of the plains area, i.e., 750 feet.

Belly River Series.

Belly River Series of the Foothills. The brackish and freshwater Belly River beds are separated from the overlying formation by a definite carbonaceous horizon, in places a coal seam. This coal seam or series of seams varies from 1 foot to 5 feet in thickness.

The series consists of alternating sandstones and sandy clays in beds up to 10 feet in thickness. Occasional, thicker beds of marine sandstone or clay deposits are met with, especially in the lower portion. At the base a massive 15-foot bed of light grey sandstone was observed and is very similar in appearance and position to the Milk River sandstone. Above this sandstone there is a thin series of blue grey shales similar to other marine shales of the district and which may be a continuation of the Pakowki shales, but it occurs in only one of the southeastern outcrops of the Belly River in the south central foothills; elsewhere it is absent. Thus, in the foothills the lower Montana is represented almost wholly by deltaic deposits.

The prairie exposures of the Belly River have been subdivided into a series of formations.

Pale Beds. G. M. Dawson divided the Belly River of the prairie into an upper "Pale series" and a lower series called the "Yellow beds". The upper Pale series have for the most part been eroded from the arching beds and will probably not be encountered in drilling for gas and oil. They consist, in the upper part, of greyish white, incoherent sandstone, and of various light-coloured sandstones and dark clays beneath. Associated with the strata are numerous, thin, carbonaceous streaks and large numbers of rather small indigo-coloured ironstone nodules containing impressions of plant fragments.

It was found during the field work of the Geological Survey in 1915 that Dawson's yellow beds should, in part at least, be subdivided into three divisions which are called in descending order Foremost beds, Pakowki shales, and Milk River sandstones[1].

Foremost Beds. This is a coal-bearing horizon having coal seams at the top and base of the division. The strata are interbedded sandstones and clays and hard ironstone layers are very frequent. The fossils are nearly all Montana brackish water species; thickness 150 to 300 feet.

Pakowki Shales. A series of dark grey clays with marine Montana fossils underlie the Foremost beds. These beds are the northwestern deposition on the edge of the lower Pierre sea and they consequently exhibit a distinct wedging out westward and are not observed in the strata of the foothills.

In the drillable area of the prairie they measure about 200 feet thick on the western limb of the arch, 350 feet at the crest of the arch, and about 800 feet in the farthest east borings (at Medicine Hat).

Milk River Sandstones. These sandstones are massive, light grey, coarse, porous sandstones in exposures near the top of the arch at the International Boundary, and also in well borings 40 miles due north; but eastward, at Medicine Hat, there is merely a thin, brown, sandy shale horizon to represent the beds. A coal bed is sometimes encountered at the top. The formation is 316 feet thick on the arch near the United States boundary, about 250 feet thick at the Bow Island gas wells, and about 10 feet thick on the east limb at Medicine Hat. Formations below the Milk River sandstone are not exposed on the Canadian prairie. The following descriptions apply to exposures in the foothills.

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[1] Geol. Surv., Can., Mem. 93.

Colorado Formation.

This thick, marine series of beds is the most easily identifiable formation of the region. The beds are a dark blue-black, sandy clay-shale with numerous ironstone concretions. Near the base are several hard sandstone members. The formation contains numerous marine fossils of the Colorado group. There are from 1,100 to 2,000 feet of strata; the actual thickness is somewhat indeterminate owing to the effect of crumpling and faulting on the soft beds.

Blairmore Formation.

The Colorado formation overlies a thick sandstone series of which the upper part has been tentatively correlated with deposits of Dakota age partly on the authority of stratigraphic sequence. In the eastern foothills about 950 feet of beds are referable to this division, the upper part of which consists of rapidly alternating, thin-bedded, vari-coloured sandstones and shales. The colours are greens, yellows, reds, browns, and purples, all of dark shades. A deep maroon-red shale near the top is particularly typical. The shale layers are very soft whereas the sandstones are extremely hard. The contact with the Colorado shale is somewhat abrupt. The upper bed of the Blairmore is a dark, coarse sandstone or in some places a conglomerate containing small pebbles which vary rapidly in the size of the grains. The bed also varies in thickness, from 6 feet to zero.

No fossils were observed in any of the upper beds, but in the lower strata plant remains were found showing that some of the deposits originated on land. Throughout the formation conglomeratic lenses are of common occurrence and suggest river deposition.

Kootenay Formation.

In the foothills below the Blairmore there is exposed a group of Lower Cretaceous beds distinguished mainly by being coal-bearing to a pronounced degree. Its age has been determined chiefly on fossil plant evidence.

The included strata are said to be over 5,000 feet thick in places west of the front range, but the farthest east exposures are not more than 400 feet. Drill records of borings on the eastern edge of the disturbed belt indicate a series of coal-bearing beds, 950 feet below the top of the Blairmore, which are undoubtedly Kootenay. The included strata consist of dark, coarse sandstone and thick beds of black, carbonaceous clay and shales. The deepest drilling in the foothills has not penetrated more than 300 feet into the Kootenay.

DESCRIPTION OF THE UNEXPOSED PRAIRIE FORMATIONS FROM WELL RECORDS.

The United Oil Company's well No. 3, situated in the mid-portion of the prairie uplift about 30 miles north of the United States boundary, has furnished the following data concerning the unexposed stratigraphy of the prairie.

The top of the well is near the base of the Foremost beds. In the records the Pakowki shales are about 375 feet and the Milk River beds 125 feet thick.

Colorado Formation.

The typical blue-black Colorado consists mostly of shales, with sandy shales and fine sandstones occurring at intervals. Frequent layers of white bentonite and ironstone are noted in drill samples. The thickness is 1,810 feet. An horizon of coarse sediments occurs 480 feet above the base which in this well contains two gas sands with a combined flow of some 12,000,000 cubic feet. This is the same horizon as that of the Bow Island gas field 36 miles north. The thickness of beds, at the gas horizon, including the sandstones and fine conglomerates, is 180 feet. Brackish water occurs 70 feet above the gas in the lower part of the lower gas sand and again 180 feet below the lower gas. The lower water is under heavy pressure and flows several thousand barrels per day.

Blairmore Formation.

Underlying the black shales of the Colorado is a dark, fine sandstone succeeded by green, blue, brick-red, maroon shales and green sandstones. The variety of shales and sandstones occurring in a single 5-foot sample indicates that the beds are thinly bedded. These drill samples are so much like those from drill holes in the foothills brought up from beds immediately underlying the Colorado, that if placed together unlabelled it is hardly possible to again differentiate them. Such similarities in lithological characters at exactly the same horizon are sufficient criteria to assign the beds underlying the Colorado of the prairie to the same formation as in the foothills.

A complete sample record of the upper 140 feet of the Blairmore was preserved. Below that depth there is 115 feet with no sample record, but it is marked on the driller's log as grey-white shale. Below this, samples for 25 feet show light grey sandstone and blue and light green shale. Again there is a gap in the samples recorded on the log as " pink shale " underlaid by 10 feet of " black slate shale " which has a brackish water sandstone underneath. Succeeding this is 110 feet of maltha-soaked sandstone which was taken from the drill hole in large plastic masses.

Beneath the heavy oil bed is a fine, light-coloured quartzose limestone. Many samples were impregnated with maltha which may not have been included with the original rock but may have seeped from above as the hole was not cased at this depth. These siliceous limestones continue for 55 feet and are replaced by 40 feet of grey shale.

Palæozoic.

Pure white limestone succeeds the shale. The limestone is continuous in the samples for 350 feet and is followed by dark green, calcareous shales for 125 feet to the bottom of the well. There is a reported showing of gas and oil at the junction of the calcareous shale and the limestone. The brackish water horizon just above the maltha sandstone suggests the existence of an intercalated marine series.

It is particularly noteworthy that in southern Alberta there is a very thick maltha-saturated bed having the same relation to the Mesozoic and Palæozoic systems as has the bituminous beds of the McMurray district many miles to the north.

CENTRAL ALBERTA.

BOW RIVER TO NORTH SASKATCHEWAN RIVER.

HISTORICAL GEOLOGY.

In central Alberta there is a contrast to the southern region just described in that the sediments were directly influenced by advances and retreats of the western shore-line. In this northern part the shore-line was farther to the west and had less influence on the deposition.

The Colorado, as in southern Alberta, is probably represented by continuous marine deposition, though possibly the sediments are not quite so thick. In central Alberta there was probably a continuous marine condition from the beginning of the Colorado, well into the Montana epoch, as there is apparently no brackish or even shallow water sediments separating the lower Pierre formation from the Colorado marine shale. All the information on the Cretaceous below the Montana group has been obtained from a few poorly preserved well records which leave much to be desired.

The Montana is represented as beginning with a period of considerable marine deposition (Lea Park formation), followed by an uplift which resulted in brackish water sedimentation amounting to 200 feet of sandy clays and carbonaceous clays (Ribstone Creek formation). There was a subsequent advance of the sea only long enough to deposit 50 to 100 feet of marine beds (Grizzly Bear formation), followed by 250 to 300 feet of brackish water sediments (Birch Lake sandstones and the Variegated beds). Continental deposits or freshwater beds are next found, having a thickness of 500 feet (Pale beds). A third advance of the sea followed the continental conditions. This marine period was probably quite as long or longer in duration than the first advance of the Montana sea and marine sediments were formed to a depth of 700 feet (upper Pierre or Bearpaw). The Montana epoch was followed by brackish water and coal-forming conditions (Edmonton formation).

STRUCTURAL GEOLOGY.

The low anticlinal structure underlying the southern plains does not prevail north of Red Deer river in Alberta. The structure seems to be in its larger aspects either a terrace or a monocline, for as one travels northeastward across the region succeeding lower beds are exposed to view.

The dip of the beds along the western central plains area is noticeably southwestward, but to the northeast, at least as far as the Saskatchewan boundary, the beds have an apparently horizontal attitude which is in reality a low upgrade.

From the vicinity of the Neutral hills the boundary between the Bearpaw and Pale beds meets the horizon along a line running northwest

southeast. Southward the trend of this boundary is southwest or northeast and the dip is northwest, that is an abrupt change of strike occurs in the Neutral Hills area. Within the southwesterly pitching depression formed by these two opposing dips a considerable amount of minor folding and crumpling has taken place. This folding and crumpling is apparently localized eastward and westward along the line where the beds of the plains assume an appreciable dip into the synclinal basin westward. The folds where they are at all well defined exhibit a crescentic trend of their axial lines. Neutral and Misty hills are underlain by synclinal or monoclinal structures and the intervening valleys are eroded anticlines.

STRATIGRAPHY.

All the strata exposed belong to the Edmonton formation and to the Montana group of the Cretaceous.

Edmonton Formation.

The rocks of this formation consist chiefly of green, sandy clays and grey sandstones. Numerous coal seams occur. As this formation occupies the Alberta syncline it is not of particular importance in the petroleum geology of the country.

Correlation Table for Montana Group.

Outer foothills	Southern Alberta	Central Alberta
Pierre-Foxhill of early reports.	Bearpaw.	Bearpaw.
Belly River series. Pale beds.	Pale beds.	Pale beds.
Belly River series. Yellow beds.	Foremost beds.	Variegated beds.
		Birch Lake sandstone.
		Grizzly Bear formation.
		Ribstone Creek formation.
	Pakowki shale.	Lea Park formation.
	Milk River sandstone.	Probably not present.

Bearpaw (Upper Pierre) Formation.

This formation consists of dark, slate-like shales containing large numbers of selenite crystals and ironstone nodules. In the lower part, sandy horizons are plentiful, and a particularly hard sandstone member called the Bulwark sandstone is very noticeable in that it caps the summits of some of the higher elevations such as Flagstaff and Neutral hills. The formation, according to Tyrrell, is 600 to 700 feet thick. Typical marine Pierre fossils are well represented.

Pale Beds.

These are identical in appearance and composition with the Pale beds of the south and are a continental deposition of incoherent, light grey

sandstone with greenish clays containing small indigo-coloured ironstone nodules with plant fragments. Thin carbonaceous beds occur, but the coal beds so prominent at the top of the southern Pale beds do not seem to extend into central Alberta. Freshwater invertebrates are found throughout the Pale beds. The thickness is estimated at 500 feet.

Variegated Beds.

The name has been given to a series of thinly-bedded clays an sandstones exhibiting some variety of colouring. Thin, carbonaceou shales occur in the lower part. These beds underlie the Pale beds and are about 200 feet thick.

Birch Lake Sandstone.

A massive, yellow weathering sandstone underlies the Variegated beds. It shows irregular degrees of hardness and cross-bedding. Large sandstone concretions occur. This sandstone is from 60 to 100 feet thick. A species of brackish water *Ostrea* is found in lower beds of the Birch Lake sandstone.

Grizzly Bear Formation.

A marine shale horizon containing various Montana marine fossils underlies the Birch Lake sandstone. The shale is dark grey in colour and is not less than 50 feet or more than 100 feet thick. Exposures are few and unsatisfactory.

Ribstone Creek Formation.

Only the upper beds of the formation are exposed in the areas examined. The upper rocks are incoherent, greenish yellow sands confusingly similar to the Birch Lake sandstone. This sandstone is at least 65 feet thick. The underlying beds are indicated by drill-hole records to be carbonaceous and clay shales with a coarse sandstone at the base 20 to 40 feet thick containing saline water.

Lea Park Formation.

This formation is a dark, slate-grey shale and is exposed at the mouth of Vermilion river. Marine Montana fossils are plentiful.

UNEXPOSED STRATA FROM WELL RECORDS.

The data from well records are meagre and unsatisfactory. For 1,450 feet below the base of the Ribstone Creek formation dark clay shales predominate. Part of these comprise the Lea Park formation and the remainder belong to a marine phase of the Colorado group. Below this, the Colorado strata become sandy. In the upper part of these sandy beds the main gas flow of the Viking district is obtained. These sands have been explored by drilling for about 200 feet deeper and gas, saline waters, and a small quantity of heavy asphaltic oil have been obtained.

PETROLEUM HORIZONS OF THE FOOTHILLS.

The Paskapoo, Edmonton, Bearpaw, and Belly River formations in the foothills have shown no indication of ever having been petroliferous. From the nature of these upper beds it is safe to overlook them when considering petroleum-bearing rocks.

The Colorado group in Canada has not, up to the present time, been found to contain oil in appreciable amount. Certain small bodies of petrolific shale have been noted and some of the lower sandy members are of sufficient porosity to be gas reservoirs. These shales act as a cap-rock arresting the migration of the underlying oil and may have been the original source of some of the petroleum.

The strata underlying the Colorado are the proved oil-bearing rocks of the foothills. Included in the strata, so far as has been determined, are four oil horizons as follows:

Oil sand No. 1. The uppermost bed of the Blairmore formation.
" No. 2. 500 feet below the top of the Blairmore.
" No. 3. 1,100 feet below the top of the Blairmore and in the Kootenay formation.
" No. 4. About 200 feet below No. 3.

The top bed of the oil sand No. 1 is the only one of these horizons that has been recognized in surface exposures. On the outcrop it generally weathers to a rusty red, but in places is stained white to light yellow. On a fresh fracture the rock is jet black with a glistering surface caused by minute crystals of pyrite.

The sandstone is at some places thin-bedded and at others it is massive, coarse-grained, and even conglomeratic. Paraffin stains are observed along the bedding and jointing and in one or two localities very porous phases are saturated with petroleum.

All exposures of the shale and sandstone directly beneath the oil sand show no indications of ever having been petroliferous.

No. 1 oil sand yields a 30-barrels per day production in the Alberta Petroleum Consolidated Oil Company's well No. 1 on the west flank of the Turner Valley anticline.

No. 2 oil sand is a light grey, medium-grained sandstone. This horizon does not appear to be of any great importance. The Prudential Oil Company's well No. 1 obtained about five barrels daily from this horizon.

No. 3 oil sand is a light grey sandstone of medium grain and porosity and is about 20 feet thick. The greatest production in the Turner valley is obtained from this sand by the Southern Alberta Oil Company's well No. 1 on the east flank of the anticline. The oil flows at intermittent intervals from a depth of 3,575 feet. The Calgary Petroleum Products Oil Company also obtains oil from this horizon in No. 1 and No. 2 wells.

No. 4 oil sand is a dark, hard but porous sandstone underlying a considerable thickness of carbonaceous shales.

It is quite possible that other deeper oil horizons will be encountered.

NATURAL GAS, WATER, AND PETROLEUM HORIZONS, SOUTHERN PLAINS.

Natural Gas.

The Milk River sandstones when penetrated by the drill produce either freshwater or natural gas, depending upon structural conditions, i.e., on the crest or west slope of the uplift water is obtained whereas on the east slope gas occurs in this sandstone.

Two or three gas horizons occur in the upper Colorado, but the total yield from these is not over 50,000 cubic feet per day. The Bow Island gas sand is the main productive horizon and is in the lower part of the Colorado shales, the part that in the eastern plains is called *Benton*; it is about 400 feet above the base of the formation. The gas is found in two sands about 30 feet apart. The production per well varies from 5,000,000 cubic feet to 20,000,000 cubic feet with a 700-pound rock pressure.

Water.

The fresh water in the Milk River sandstone is derived from Milk river which flows along the northerly dipping outcrops of these beds.

The salt water or brackish water occurring at different horizons are probably remnants of the waters of the original seas in which the marine sediments were deposited.

In southern Alberta the water flows from the wells under considerable pressure. Some of this pressure is undoubtedly due to a static head from the west, but probably the greater part comes from gas accumulations along the water sand.

Petroleum.

As mentioned above, the United Oil Company's well No. 3 obtained a quantity of thick petroleum in strata overlying Palæozoic rocks. With this maltha occurred large quantities of pyrite and other sulphur compounds—copious fumes of hydrogen sulphide resulted from treatment with hydrochloric acid. The bed is about 110 feet thick; a salt water flow occurred about 80 feet above the oil. Some 450 feet below the oil sand and in the limestones a showing of gas and oil was reported.

The Grand Trunk Pacific Development Company drilled a well through all the strata to the upper part of the limestone a few hundred feet north of the United States boundary near the West butte of the Sweetgrass hills. In this well the horizon equivalent to the maltha sand yielded a vaseline-like substance.

A well was drilled by the Beaver Oil Company with a rotary-hydraulic drill, on the north bank of Milk river about 20 miles due south of the United No. 3 well. Rotary drills do not give accurate sample records, but it has been determined that the United well is 285 feet higher stratigraphically than the Beaver well. The following is a record of oil, gas, and water sands in the Beaver well and the equivalent horizons in the United Oil Company's well.

Beaver.		United No. 3.	
Fresh water	165 feet.	Fresh water	450 feet.
Oil showing	765 "	Water	1050 "
Strong gas flow	1705 "	1990 feet gas at	2020 "
Oil showing	1890 "		
Salt water	2645–90 "	2930–75 salt water	2920 "
Distinct oil seepage	2690 "	2975 maltha at	2990 "
Water sand		No water below at United Oil Company.	

The Beaver well records, said to be kept by the drillers, were obtained indirectly by the Geological Survey and are not vouched for, except the oil seepage at 2,690 feet, which, at the present time, is still coming from the well with the water flow. This occurrence affords some promise that

bodies of fluid petroleum may be found replacing the thick maltha. The strong flow of salt water below the oil in the Beaver well prevented further testing of the horizon.

The deposits of thick oil discovered by the United well are of no commercial value under existing conditions, but they are of considerable importance and interest to the geologist looking for petroleum as they indicate a seemingly very promising petrolific horizon. They also form an interesting occurrence of apparently inspissated petroleum several hundred feet below oxidation zones.

GAS, WATER, AND OIL HORIZONS OF THE CENTRAL PLAINS.

Gas.

Small, rather unimportant gas flows are obtained from beds of the Belly River series. Gas from one of these horizons has been put to commercial use by the municipality of Castor.

The Colorado formations yield small flows of gas down to the important gas sands of the Viking district.

The Viking gas sand is a sandy member of the lower Colorado. The top of the sand is about 1,450 feet below the Ribstone Creek formation. From this horizon the wells near Viking obtain open flow measurements of 2,000,000 to 7,000,000 cubic feet per day.

Water.

Potable well waters are obtained in drill-holes penetrating the upper part of the Pale beds in the vicinity of Coronation, Monitor, and Fusilier.

Good water is obtained from the Birch Lake sandstone in wells around Wainwright and copious springs from this sandstone occur along the Battle River coulee.

Saline waters were encountered in the lower sandstone of the Ribstone Creek formation by the wells at Viking and the well near Irma. Saline waters were found in the lower part of the gas horizons in some of the wells at Viking.

Oil.

A small showing of oil was obtained in the Irma well at the top of the lower sandstone of the Ribstone Creek formation. Other oil "shows" in this district were at 1,215 and 1,582 feet below the surface in the Colorado beds.

Distinct oil seepages occur in the lower part of the Viking gas sands; it is a heavy asphaltic oil.

PART III.

THE CRETACEOUS OF PEACE AND ATHABASKA VALLEYS.

By

F H. McLearn.

PART III.

The Cretaceous of Peace and Athabaska Valleys.[1]

INTRODUCTION.

The following preliminary description of the Cretaceous of northern Alberta is based on a study of the Peace valley from Dunvegan to Vermilion chutes and of the Athabaska from Athabaska Landing almost to the mouth of Firebag river.

Acknowledgments are made to D. B. Dowling for aid received in the preparation of this preliminary report and to Dr. T. W. Stanton of the United States Geological Survey for advice in the identification and interpretation of the fossils.

The strata exposed belong chiefly to the Colorado group of the Upper Cretaceous and to a group of Lower Cretaceous age. Characteristics of the succession are the presence of marine deposits in the Lower Cretaceous, and of non-marine beds in the Colorado, recalling those of the Belly River series in the Montana group.

Since the term Lower Cretaceous, as a major division of Cretaceous time, does not everywhere receive the same interpretation, it is well to define it as adopted here. It is construed as embracing the pre-Cenomanian Cretaceous in terms of the European classification, This accords best with our present knowledge of the local succession and follows the general usage of the plains. This rendition of Lower Cretaceous, however, is not presented as a final one.

LOWER CRETACEOUS.

In the Peace section the Lower Cretaceous includes the Loon River and Peace River formations and in the Athabaska section the McMurray tar sands, Clearwater formation, and Grand Rapids formation. These form a well-defined group, marked by a broadly parallel physical development in both sections and a similar marine fauna in the Peace River, Loon River, and Clearwater formations. This group will hereafter be referred to as the " Lower Cretaceous " group.

MCMURRAY TAR SANDS.

This is the basal formation of the Cretaceous in the Athabaska section. Its relation to the underlying Devonian limestone is that of unconformity. It outcrops, as intermittent cliffs, from Boiler rapids almost to Firebag river. The full thickness is first revealed at Crooked rapids, where it amounts to 110 feet. The thickness increases in the direction of McMurray, where it is 180 feet. Above, this formation consists of thick-bedded

[1] For further treatment of the correlation and for more complete faunal lists see Geol. Surv. Can., Sum. Rept.; 1918, pt. C, pp. 1C-7C.

sandstone and argillaceous sandstone, which, below, passes into massive, cross-bedded, clean, and coarse-grained sandstone. In parts of the area, the beds of the lower part are inclined 8 degrees or less to those of the upper part, and this produces cross-bedding on a very large scale. The large scale cross-bedding, in places, gives rise to quite abrupt lithological changes laterally. A small fauna of freshwater origin is present, chiefly in the upper part.

CLEARWATER FORMATION.

The Clearwater overlies the tar sands in the Athabaska section and outcrops, on the valley sides, from point La Biche to some distance below McMurray, and, near McMurray and north, underlies the plateaus adjacent to the river. The thickness is 275 feet. The formation is made up of bedded grey and green sandstones and grey, greenish, and black shales, with ironstone concretions. A marine fauna is found throughout and includes *Desmoceras affine, Hoplites mcconnelli, H. mcconnelli* var., *Inoceramus dowlingi, Brachydontes athabaskaensis,* and *Tellina dowlingi.* The contact between this formation and the underlying McMurray tar sands is drawn at the bottom of a green, sandy shale or sandstone which marks the passage from the non-marine conditions of the tar sands to the marine environment of the Clearwater. This green bed is located at the top of nearly all the tar sand cliffs and is recommended as a horizon marker for structural studies in this district.

GRAND RAPIDS FORMATION.

The Grand Rapids follows the Clearwater on the Athabaska. It outcrops on the valley sides from about 3 miles south of rapide du Joli Fou to a few miles below the Cascade, and on the plateaus adjacent to the river from Algar river to below the Cascade. It is 280 feet thick.

It consists almost entirely of massive and cross-bedded sandstone. The lower part is marked by the presence of very large concretions and forms a cliff above river-level for miles below Grand rapids. The upper part contains only a few flat concretions and forms two cliffs above that of the concretionary member. The base of the formation is of marine origin, as shown by the presence of marine bivalves; but, upwards, subaerial conditions of deposition are recorded by the presence of discontinuous lignite seams, with vertical rootlets in the subjacent sandstone.

LOON RIVER FORMATION.

The Loon River formation lies at the base of the Cretaceous in the Peace section. It outcrops on the valley sides from a few miles below Brown's trading post to Vermilion chutes, where it is underlain by limestone of Devonian age. It underlies the plateaus north and east of the great horseshoe bend. The thickness in the bore-holes in the south is about 1,100 feet; it is 300 feet (estimated) at the great horseshoe bend in the north. As exposed along the valley in the north, the formation consists of dark, friable shale with a few small rounded concretions or flat concretionary bands and a few thin beds of sandstone. A few marine fossils are found. Their presence, together with the thin bedding and the

absence of any evidence of subaerial deposition, points to the prevalence of marine conditions in the north throughout Loon River time. In the south, where penetrated by the bore-holes of the Peace River Oil Company, the formation is more arenaceous. This is especially true of the lower part, where the sandstone beds carrying the oil are very thick. These lie at the horizon of the tar sands, are probably non-marine, and represent with the tar sands the early non-marine stage of the Lower Cretaceous. The remainder of the Loon River and the basal beds of the Peace River may be compared broadly with the Clearwater on the Athabaska and represent with the latter a marine stage. The fauna includes *Desmoceras affine*, and *D. affine* var. *glabrum*.

PEACE RIVER FORMATION.

The Peace River overlies the Loon River in the Peace valley and is exposed along the river from the town of Peace River almost to Carcajou point. The maximum total thickness is 320 feet. The formation consists of two sandstone members separated by a shale member. On the valley sides it outcrops in two sandstone cliffs separated by a bench on the shale. In the south the upper sandstone member is massive, cross-bedded, contains some lignite near the top, and is 130 feet thick; this is a subaerial development. Northward it decreases in thickness and becomes replaced by bedded sandstone and shale with a few marine fossils. Finally toward Carcajou point it is wholly replaced by marine shale. The middle shale member is only 30 feet thick and consists of blue black, friable shale. The lower sandstone member is massive, with large concretions above, and grades downward into thin-bedded sandstone and shale with marine fossils. In the south the thickness is 160 feet. The lower member decreases northward; below Battle river it is 80 feet and near Carcajou point only 20 feet. This formation shows a strong resemblance to the Grand rapids of the Athabaska valleys, in the presence of concretionary sandstone below and of massive lignite-bearing sandstone above; the upper part of each formation represents the late non-marine phase of the Lower Cretaceous group. The marine fauna includes *Desmoceras affine*, *D. affine* var. *glabrum*, *Hoplites mcconnelli* var., *H. canadensis*, *Panopæa* cf. *subovalis*, *Tellina dowlingi*, *Pinna curvi marginata*, *Trigonia albertaensis*, *Dicranodonta dowlingi*, and *Nemodon mcconnelli*.

CORRELATION.

The marine fauna of the Lower Cretaceous group is quite unlike that of any described American Cretaceous fauna. The affinities of the ammonites and of *Inoceramus* indicate a Lower Cretaceous age. Further it would only be safe to say at present that these affinities point to later rather than earlier Lower Cretaceous; the absence of *Aucella* in particular suggests this. The age is a little earlier than Dakota; for the latter is not considered to be older than Cenomanian and the affinities of this fauna are pre-Cenomanian.

UPPER CRETACEOUS (DAKOTA).

Dakota, *in the strict sense*, has not been recognized in northern Alberta. There are three possibilities: (1) it is represented, in its normal subaerial

development, by the very top of the Peace River and Grand Rapids formations, but the flora is not preserved whereby it could be identified; (2) it is represented in time, as a marine development, by a part of the St. John and Pelican shale formations; or (3) there was no deposition in this part of Alberta in Dakota time.

UPPER CRETACEOUS (COLORADO GROUP).

The Colorado group includes in the Peace valley the St. John, Dunvegan, and a part of the Smoky River formations, and, in the Athabaska valley, the Pelican shale, Pelican sandstone, and lower La Biche formation.

ST. JOHN FORMATION.

The St. John overlies the Peace River formation. It outcrops in the valley of Peace river from the bend below Burnt river almost to the great horseshoe bend in the north and underlies the plateaus adjacent to the valley north of the town of Peace River. The thickness at Peace River is 560 feet (estimated). It consists of marine, dark blue to grey, friable shale with a few concretions. In the west it is fossiliferous near St. John. The fauna includes *Acanthoceras cornutum*, *Nucula dowlingi*, and *Inoceramus* sp.

DUNVEGAN FORMATION.

The light, massive, cross-bedded sandstones of this formation follow the shales of the St. John in the Peace section. East and northeast of Dunvegan, they outcrop in cliffs downstream to the south boundary of township 82. The thickness is about 530 feet on Peace river. The small fauna contains freshwater, brackish-water, and marine forms and includes *Unio dowlingi*, *Corbula pyriformis*, *Ostraea anomioides*, *Brachydontes multilinigera*, *Barbatia micronema*, and *Inoceramus*.

SMOKY RIVER FORMATION.

The basal shales of this formation outcrop at the top of the cliffs of Dunvegan sandstone in the vicinity of Dunvegan.

PELICAN SHALE.

In the Athabaska section this formation overlies the Grand Rapids sandstone. It forms a bench on the valley sides between the cliff of Pelican sandstone above and the Grand Rapids sandstone cliff below and outcrops from Stony rapids to point Brulé. It consists of 90 feet of marine dark shale with fragmental remains of *Inoceramus*.

PELICAN SANDSTONE.

The Pelican shale passes up into non-marine, cross-bedded sandstone, in places conglomeratic at the top. The thickness is 35 feet. It outcrops from a short distance below Pelican rapids to near point Brulé, forming a sandstone cliff above the bench on the Pelican shale.

LA BICHE FORMATION.

This formation consists of dark marine shales and follows the Pelican sandstone in the Athabaska section. It outcrops from Athabaska to point Brulé. The total thickness is over 1,100 feet. The lower part, which is referred to the Colorado, first appears at Stony rapids. It carries there a small fauna including *Prionotropis* cf. *woolgari* and *Inoceramus* sp.

CORRELATION.

The formations referred to the Colorado group in this region are sparsely fossiliferous. The lower La Biche contains *Prionotropis* with Coloradoan affinities. The St. John contains a type of ammonite not known before the Colorado. The Dunvegan contains the Colorado bivalves *Ostraea anomioides, Barbatia micronema,* and *Brachydontes multilinigera;* the presence of the Bear River *Corbula pyriformis* indicates affinities not later than Colorado. The lower part of the Smoky River formation contains numerous Coloradoan fossils.[1] The upper La Biche and the upper Smoky River are of Montanan age.

STRUCTURE.

The structure of the Cretaceous on the Athabaska and Peace rivers may be described as one of large scale and very gentle undulation.

ATHABASKA SECTION.

A south dip is revealed in the north-south section cut by the Athabaska river from Athabaska to point Brulé. In the north this amounts to 5 feet or less per mile, but in the south, to carry the strata to their position in the Athabaska bore-hole, a steepening of the dip to 10 feet per mile is required. The east-northeast section exposed fron point Brulé to McMurray shows a very low anticlinal structure with the axis near Crooked rapids and on either side very low dips, 3 or 4 feet per mile. North of McMurray the section exposed on the river, as far as it can be determined, shows a flat or slightly north dip. The actual structure, as revealed in these sections, strikes northwest or north-northwest and may be described as a low anticlinal structure with a long, low dipping, southwest limb and a short, very low dipping, northeast limb. The relation of this structure to the central plains terrace may be seen by examining sketch map No. 1779 in the report of D. B. Dowling.

PEACE SECTION.

North of the town of Peace River a north-south section is cut by the river. At the town the average dip is 10 feet per mile to the south. Near the No. 2 well of the Peace River Oil Company, and from there to Tar island, the structure is almost flat, but may have a slight rise of 1 or 2 feet per mile north. Downstream there is a slight dip north, of a few feet per mile, to a point about 10 miles below the mouth of Cadotte river. Beyond this is a gentle rise and a final flattening out. The above structure applies

[1] Sum. Rept., Geol. Surv., Can., 1918, part C, p. 4C.

to the rocks above river-level. It is probable that the strata below river-level, which would be encountered in drilling, do not have quite the same structure. This applies in particular to the section north of Tar island. The limestone contact rises northward and the Loon River shales decrease in thickness. If this is due to the deposition of the Loon River in a sinking geosyncline, with its axis to the south or southwest, then the lower beds are tilted slightly south as compared with the rocks above river-level. Therefore, where the dip above is to the north, it may be almost flat below, and, where the dip is flat above, it may be inclined a little to the south below. For the relation of this structure to the major structure of the plains, sketch map No. 1779 of the report of D. B. Dowling should be examined.

ECONOMIC GEOLOGY.

OIL AND GAS HORIZON.

The possibility of the presence of oil and gas in this district is a part of the general problem of their occurrence in the Great Plains; the report of D. B. Dowling should, therefore, be consulted in this regard. Details of the location, depth below surface, and nature of the oil and gas-bearing horizons are given below.

The oil-bearing horizon of this district is embraced in the sandstones at the base of the Lower Cretaceous group. In the Peace section thay are the sandstones of the lower part of the Loon River formation. In No. 2 well of the Peace River Oil Company, oil has been found at two horizons, in each case a bed of sandstone. The upper bed, 106 feet thick, was found from 842 feet to 948 feet in the bore-hole, or 810 feet to 916 feet below river-level. It carried a very heavy oil from 852 feet to 905 feet and salt water from 905 feet to 910 feet. The lower sandstone, separated from the upper by 14 feet of shale, is 95 + feet thick and occurs from 962 feet to 1,057 + feet, or 930 feet to 1,025 + feet below river-level. It carries oil from 962 to 1,032 feet, water from 1,032 to 1,035 feet, is imporous from 1,035 to 1,043 feet, and contains tar from 1,043 to 1,047. The oil here is of better quality, but still heavy, and may be expected to yield a few barrels per day. The sand beds thin northward, due to replacement by shale. In well No. 1, 1½ miles north, the top sandstone thins to 70 feet, the separating shale increases to 53 feet, and the lower sandstone decreases to 65 feet. This thinning of sandstone lenses evidently continues northward; for near Vermilion and downstream, where the lowest strata of the Loon River outcrops, the sandstone is entirely replaced by shale. It is evident that this limits the area of exploration northward; since no oil can be expected beyond the extent of the porous sandstone reservoir. Just where these sandstones finally thin out, it is impossible to say; but exploration north of Tar island would be attended with some risk on this account. The depth of the oil-bearing horizon below river-level decreases northward. At the town of Peace River the top of the lower sandstone is about 1,100 feet or less below river-level; at well No. 2 it is 930 feet below river-level; at Carcajou point, it is at least 300 feet (estimated) below river-level, assuming that sandstone persists that far north.

In the Athabaska valley the problem is—will the tar sands yield oil? The tar sands outcrop downstream from Boiler rapids. At Pelican, the top is about 750 feet below river level. The cover increases southward and should be about 1,780 to 1,800 feet at Athabaska Landing. It was hoped by the early geologists that the tar of the surface outcrops was a residue resulting from the surface-weathering of a liquid oil. In the wells at Pelican, however, where the tar sands are under about 750 feet of cover and 59 miles from the outcrop, only tar and heavy maltha were found. The shallow wells of the Athabaska Oil, Limited, opposite the mouth of Namur river, exhibit a tendency for a somewhat more liquid product, a heavy oil, to collect in a depression of the limestone contact; this might be expected in a dry horizon.

On both the Peace and Athabaska rivers, the sandstones at the base of the Lower Cretaceous also carry gas in variable amounts. Two wells at Pelican have each yielded a large flow of gas. The upper oil-bearing sandstone in the No. 2 well at Peace River carries gas. The La Biche carries small quantities of "shale" gas.

APPENDIX.

RECORDS OF SELECTED WELLS ARRANGED IN EAST-WEST ORDER.

Compiled by D. B. Dowling.

LIST OF WELLS (see Relief map No. 1774).

1. Morden.
2. Snowflake.
3. Manitou.
4. Rathwell.
5. Neepawa.
6. Riding mountain.
7. Vermilion river.
8. Deloraine.
9. Bottineau county, N. D.
10. Kamsack.
11. Fort Pelly.
12. Eastlin.
13. Wilcox.
14. Belle Plaine.
15. Moosejaw.
16. Ralph.
17. Langham.
18. Maple Creek.
19. Medicine Hat.
20. Drowning Ford.
21. Fusilier.
22. Sweet Grass.
23. Etzikom.
24. Foremost.
25. Bow Island.
26. Alderson.
27. Kevin, Mont.
28. Tabor.
29. Brooks.
30. Cassils.
31. Castor.
32. Hawkins.
33. Viking No. 1.
34. Vegreville.
35. Victoria.
36. Lethbridge.
37. Kipp.
38. Gleichen.
39. Calgary.
40. Ponoka.
41. Wetaskiwin.
42. Camrose.
43. Tofield.
44. East Edmonton.
45. Edmonton.
46. Morinville.
47. Athabaska.
48. Pelican No. 1.
49. Pelican Rapids.
50. House River.
51. McMurray.
52. Peace River.

1. *Morden.*[1]

Boring about 150 yards northwest of the railway station.
Elevation: 978 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Alluvium, 15 feet.	Soil, light, sandy	8	8
	Quicksand	3	11
	Quicksand, red	1	12
	Gravel, fine, red	3	15
Till, 16 feet.	Clay, lead-coloured, with pebbles	10	25
	Limestone boulder, with fine scratches	2·5	27·5
	Boulders, small, and shale	3·5	31
Pierre[2] (Millwood series) 24 feet.	Shale, dark grey	24	55
Niobrara, 160 feet.	Streak, hard	0·5	55·5
	Shale, dark grey	4·5	60
	Streak, hard	3	63
	Shale, dark grey	6	69
	Streak, hard	1	70
	Shale, dark grey	11	81
	Streak, hard, mixture of stones and shale	1	82
	Shale, dark grey	4	86
	Shale, black, very gritty	1	87
	Shale, dark grey	7	94
	Shale, black, hard, and gritty	1	95
	Shale, grey, calcareous	121	216
Benton, 105 feet.	Shale, dark grey	35	251
	Soapstone	3	254
	Shale, dark grey	67	321
Dakota.	Sand, white, with water	4	325
	Sand, white, with particles of coal	54	379
	Shale, white, and white sand	2	381
	Shale, soft, grey	10	391
	Shale, black	10	401
	Shale, grey, with sandstone	12	413
Devonian.	Shale, red and grey	88	501
	Limestone, porous	—	—
	Shale, red and grey	100	601

2. *Snowflake.*

Sec. 35, tp. 1, range 9, W. 1st mer.
Elevation: at Larivière on Pembina river 1,290 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface.	Stones, large, and gravel	62	62
	Shale, hard, fine sand	11	73
	Shale, black, soft, petroliferous	108	181
Niobrara shale.	Stone, soft, with oily appearance	40	221
	Shale, light-coloured, oily	15	236
	Shale, dark-coloured, oily	40	276
	Formation oily, light-coloured	35	311
	Shale, light-coloured, and sand	7	318
	Probably sand	5	323

[1]Tyrrell, J. B., Roy. Soc. Can., vol. IX (1891) IV, p. 98.
[2]Probably non-calcareous band in the Niobrara as given in Deloraine well between 1,275 feet and 1,410 feet from surface.

3. *Manitou.*

Sec. 23, tp. 2, range 9, W. 1st mer.
In valley of Pembina river.
Elevation: at Larivière, 1,200 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Niobrara and Benton.	Shale	112	112
	Shale, dark, holding some petroleum	507	619
	Soapstone	15	634
	Slate	12	646
	Shale, black	60	706
Dakota and probably lower beds.	Quartz (sand) white	31	737
	Sand	29	766
	Clay, red	18	784
	Soapstone	64	848
	Stone, soft, and blue shale	24	872
	Clay, pipe	15	887
	Clay, red, oxide	15	902
	Stone, soft, and blue shale	23	925

4. *Rathwell.*

Sec. 7, tp. 8, range 8, W. principal mer.
Bored by Provincial machine.
Elevation: 1,071 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface deposits and Benton shale.	Clay	175	175
	Quicksand and stones	20	195
	Clay, hard, and stones	78	273
	Clay and sandstone	10	283
	Shale, hard	47	330
	Shale, softer	55	385
	Shale, hard	42	427
Probably Dakota.	Sandstone, clayey	10	437
	Sandstone	15	452
	Sandstone and shale	123	575
	Shale, hard	115	690
	Sandstone	10	700
Palæozoic limestones and underlying gneisses.	Limestone	7	707
	Rock, shaly, white	37	744
	Limestone, shale	6	750
	Rock, shaly, white	35	785
	Shale, red, hard	60	845
	Limestone, hard	19	864
	Rock, red (described as granite)	36	900
	Rock (not described)	81	981
	Shale, red, hard	36	1,017
	Rock (not described)	55	1,072
	Shale, red, hard	62	1,134
	Rock, hard, flinty	178	1,312
	Rock, red, rusty	28	1,340
	Rock, grey	65	1,405
	Rock, red, rusty	56	1,461
	Rock, grey	424	1,885

5. *Neepawa.*

Sec. 33, tp. 14, range 15, W. 1st mer.
Elevation: 1,219 feet at Canadian Pacific Railway station; 1,213 feet at Canadian Northern railway.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Surface	40	40
Cretaceous shales.	Shale	130	170
	Shale, greasy	25	195
	Cement, marl	15	210
	Shale, greasy	20	230
	Ironstone, black	15	245
	Shale, greasy	186	431
	Clay, sandy	19	450
Possibly Jurassic shales.	Clay, plastic	50	500
	Cement, marl	70	570
	Clay, sticky	192	762
	Shale, hard	33	795
	Clay, white, putty	5	800
	Shale, greasy	30	830
Undivided Palæozoic.	Limestone, rock	5	835
	Clay, white, putty	35	870
	Rock, red, shale	60	930
	Rock, brown, shale	15	945
	Rock, red, shale	45	990
	Limestone, grey	15	1,005
	Shale, red, slate	05	1,010
	Limestone, soft	05	1,015
	Limestone, hard	50	1,065
	Rock, hard, grey	15	1,080
	Rock, red	5	1,085
	Rock, white	10	1,095
	Rock, blue	5	1,100
	Rock, red, streaked	15	1,115
	Rock, blue	10	1,125
	Rock, white	10	1,135
	Rock, grey, hard	5	1,140
	Rock, red	5	1,145
	Rock, white, red, and grey	80	1,225
	Clay, soft, streak rusty	10	1,235
	Sandstone, hard	60	1,295
	Rock, white, spongy	15	1,310
	Lime, grey	10	1,320
	Rock, white, clay	45	1,365
	Rock, black, shale	10	1,375
	Limestone	30	1,405
	Shale, clay, white, putty	10	1,415
	Shale, clay, yellow	20	1,435
	Limestone	55	1,590
	Formation, yellow	25	1,615
	Rock, sand, red	15	1,630
	Rock, white	45	1,675
	Rock, no description	123	1,798

6. *Riding Mountain.*

Sec. 9, tp. 18, range 15, W. 1st mer. Elevation: 1,214 feet. Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Cretaceous.	Shale	149	149
	Sandstone	82	231
	Shale	120	351

7. *Vermilion River.*[1]

Tp. 23, range 20, W. principal mer.
Elevation: 1,300 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Pierre (Millwood series).	Shale, clay, soft, dark grey	95	95
Niobrara.	Limestone, fragmental	4	99
	Shale, grey, calcareous	124	223
Benton.	Shale, dark grey, fissile	178	401
Dakota.	Sandstone, coarse, with pyrites	19	420
Devonian.	Limestone, compact, white	120	540
	Shale, clay, blue grey	10	550
	Gypsum, white	15	565
	Shale, red	110	675
	Shale and limestone	68	743
	Shale, red, at bottom		

NOTE.—It seems possible that, as in the Morden well, the shales in No. 1 are the non-calcareous band in the Niobrara. The top of the Niobrara is difficult to define. D.B.D.

8. *Deloraine.*[2]

About 100 yards north of the railway station.
Elevation: 1,644 feet.
Driller's record:

Probable formation.		Material.	Thickness in feet.	Depth from surface in feet.
Pleistocene, 91 feet.		Soil, black	3	3
		Clay, with some small pebbles	30·5	33·5
		Clay, hard, blue, with pebbles	56·5	90
		Sand, fine, black, and gravel	4	94
Pierre	Odanah, 292 feet.	Shale, light, blue-grey	56	150
		Sand, black, with water	0·5	150·5
		Shale, blue	235·5	386
	Millwood, 664 feet.	Soapstone, with thin layers of lime rock	401	787
		Clay, blue, with round "boulders"	188	975
		Shale, dark, blue-grey	75	1,050
Niobrara, 545 feet.		Shale, grey	25	1,075
		Shale, mottled, grey, calcareous	200	1,275
		Shale, dark, non-calcareous, or very slightly calcareous.	135	1,410
		Shale, grey, calcareous	185	1,595
Benton		Shale, dark, non-calcareous	205	1,800

In 1892, this hole was deepened to 1,943 feet, of which the lower 121 feet were in the Dakota sandstone. In this formation saline water was struck.[3]

[1] Tyrrell, J. B., Roy. Soc., Can., IX (1891) IV, 103.
[2] Tyrrell, J. B., Roy. Soc., Can., IX (1891) IV, 93.
[3] Geol. Surv., Can., vol. VI, p. 2A.

9. *Bottineau County, North Dakota.*

The discovery in 1907 of surface gas[1] at depths of 154 to 200 feet, in Bottineau county, North Dakota, led to the boring of a deep well on the Parker farm about 9½ miles south of Westhope. On account of its nearness to the International Boundary the log of the well is given.[2]

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Soil	2	2
	Clay, yellow, and gravel	30	32
	Clay, blue	122	154
	Gravel with sand below	16	170
	Slate, white	35	205
(Pierre?)	Sand seam, black	3	208
"	Shale (caving) soft, blue	242	450
"	"Slate," black	50	500
"	Shale (caving), blue	205	705
(Niobrara).	Limestone, yellow hard rock	5	
	Shale, blue	145	850
	Shale, sandy	10	860
(Benton?)	Shale, blue to bottom	320	1,180

10. *Kamsack.*

Tp. 29, range 32, W. 1st mer.
Well drilled by Litz and Roberts, 1909.
Elevation: 1,445 feet at station.
Driller's record:

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet and inches.
	Clay, blue	50	50
	Shale	568	618
	Coal?	0 8	618 8
	Shale	152 1	770 9
	Sand	2 0	772 9
	Rock, hard	0 3	773

11. *Fort Pelly.*

Drilled by Mr. Fairbank of Petrolia in 1874-5, for the Dominion government, near Fort Pelly.
Total depth, 501 feet. At 28 feet, fresh water was struck; at 259 feet, a calcareous band 9 feet thick was passed through.[3]

[1] Analysis of surface gas, made by Professor E. J. Babcock of the University of North Dakota.

Hydrogen	0·5
Methane	82·7
Ethylene and other illuminants	0·2
Carbon monoxide	1·2
Oxygen	3·0
Nitrogen	12·4
	100·0

B.T.U. (calculated), 886 per cubic foot.
The oxygen and nitrogen are probably in the form of air.
[2] Fifth biennial report North Dakota Geological Survey, 1908, pp. 247-248.
[3] Geol. Surv., Can., Rept. of Prog., 1875-76, p. 292.

12. *Estlin.*

Sec. 13, tp. 15, range 10, W. 2nd mer.
Well drilled by Abray and Patterson.
Elevation: 1,026 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface.	Soil	22	22
	Clay and boulders	36	58
	Sand and boulders	9	67
Upper Pierre shale.	Shale, brown	11	78
	Shale, blue	207	285
	Shale, grey	62	347
	Shale, sandy	190	537
The upper part of these beds suggests a continuation eastward of the shallow water deposits represented by the Foremost beds of the Belly River.	Rock, hard, grey	1	538
	Shale, sandy	104	642
	Rock, hard, dark	2	644
	Shale, sandy, grey	74	718
	Shale, soft, grey	150	868
	Shale, sandy	132	1,000
	Shale and rock, dark, hard	15	1,015
	Shale, sandy	8	1,023
	Sand, grey, soft	7	1,030
Lower Pierre shale.	Rock, hard, dark	4	1,034
	Shale, sandy	18	1,052
	Rock, dark, hard	3	1,055
	Shale, soft, grey	467	1,522
	Rock, dark, hard	1	1,523
Probably Niobrara.	Shale, grey, soft	56	1,579
	Rock, brown, medium hard	2	1,581
	Shale, grey, soft	18	1,599
	Rock, brown, medium hard	2	1,601
	Shale, grey, soft	24	1,625
	Rock, dark	21	1,646
	Shale, grey	85	1,731
	Shale, sandy	34	1,765
	Sand	4	1,769
	Rocks, sandy, and shales	50	1,819
Benton shales.	Rock, dark, medium hard	1	1,820
	Shale, dark, grey, soft	13	2,033
	Shale, black	46	2,079
	Shale, sandy, grey, soft	5	2,084
	Shale, black	31	2,115
	Shale, grey, soft	225	2,340
	Shale, sandy	10	2,350
	Streak, white, like gypsum		
	Shale, sandy, grey, soft	40	2,390
	Shale, grey, soft	35	2,425

13. *Wilcox.*

NE. ¼ sec. 24, tp. 13, range 20, W. 2nd mer.
Well 4 miles east of Wilcox, Sask.
Elevation: approximately 1,896·5 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface deposits.	Clay	45	45
	Clay boulder	52	97
Upper Pierre.	Shale, blue	213	310
Shallow water deposits of age of Belly River formation.	Shale, grey	420	730
	Sand, black	4	734
	Shale, grey	30	764
	Sand, black	86	850
Lower Pierre	Shale	36	886
	Shale, sandy	5	891
	Shale, grey	169	1,060
	Shale, dark	224	1,284
	Shale, grey	67	1,351
	Sand	9	1,360
Colorado shales	Shale	25	1,385
	Rock and shale alternately	22	1,407
	Rock, hard	19	1,426
	Shale	4	1,430
	Rock, hard, and shale alternately	20	1,450

14. *Belle Plaine.*[1]

Sec. 31, tp. 16, range 23, W. 2nd mer.
Elevation: 1,877 feet.
Driller's record:[2]

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Superficial	Loam, clay, dark	3	3
	Clay, yellow	11	14
Upper Pierre shale.	Clay, blue	80	94
	Shale, blue	150	244
	Shale, black	75	319
	Shale, grey	125	444
Horizon of Foremost beds.	Limestone, brown	6	450
	Shale, grey	444	894
	Rock, sand, reddish	20	914
	Shale, grey	190	1,104
	Rock, sand, hard, white	2	1,106
Lower Pierre shale.	Shale, grey, with thin layers of sand rock	200	1,306
	Shale, soft, grey	175	1,481
	Shale, black	70	1,551

[1]Dawson, Roy. Soc. Can., vol. IV, 1886, sec. IV, 9. p. 4.
[2]Interpreted by comparison with Moosejaw well.

15. *Moosejaw.*

Elevation: 1,778 feet.

The first well drilled at Moosejaw, which reached a depth of 1,060 feet, shows a shallow water deposit extending downward from a depth of 480 feet. The supposition is that this deposit represents the eastern extension of the shore deposits of the Belly River formation, distributed in the off-shore waters of the Pierre sea in its shallow period separating the upper and lower divisions. The samples from the lower part or down to a depth of 1,670 feet are not in a continuous series. A comparison with a well drilled near Wilcox seems to show that there were two shallow water periods above the Colorado, separated, as in Alberta, by marine shales. It can be said with some confidence that the top of the dark shales of the Colorado is above the 1,670-foot level and a comparison with the Wilcox section indicates that it may be somewhere about the 1,600-foot level. This correlation is suggested by comparing the section in the two wells which are near together, the position of the sandy beds at the top of the off-shore deposits in both agreeing with the supposed dip to the southwest which is greater than the difference in elevation between the two places. The gap in the Moosejaw section can be nearly filled by assuming the sand in Wilcox well at 730 feet to be the same as the sand in Moosejaw well at 890 feet.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface deposits.	Clay	5	5
	Gravel	14	19
Upper Pierre shale.	Clay, hard, grey	396	415
	Clay, hard, mouse-grey	10	425
	Clay, hard	35	460
Appear to be an extension of Pale and Foremost beds of Belly River.	Clay, sandy	20	480
	Clay, hard, grey	75	555
	Clay, sandy, grey	45	600
Horizon of shallow gas at Medicine Hat at 500 feet.	Clay, hard, grey	177	777
	Clay, hard, grey, sandy	13	790
	Clay, hard, grey	100	890
	Sand, grey	20	910
	Sand rock shale	10	920
	Shale and clay	10	930
	Sand and hard, grey clay	30	960
	Sand	8	968
	Sand, pepper and salt	42	1,010
Lower Pierre shale.	Sand, grey, and clay	10	1,020
	Clay, grey, and shale	10	1,030
	Clay, hard, grey	30	1,060
	Shale, sandy	90	1,150
	No record	70	1,220
	(One sample at 1,280 feet)		
	No record	224	1,440
	No record	67	1,511
Probably trace of Milk River sandstone.	No record	9	1,520
	No record		1,545
	No record		1,567
	No record		1,586
	No record		1,590
	No record		1,610

Compare Wilcox well.

Material.	Thickness in feet.	Depth at Wilcox. Feet.
Sand, black	4	734
Shale, grey	16	750
Shale, grey	10	760
Shale	4	
Sand, black	6	770
Sand, black	30	800
Sand	8	808
Sand, black	42	850
Shale	10	860
Shale	10	870
Shale, 16 feet		
Clay, sandy, 5 feet		
Shale, grey, 9 feet	30	900
Shale, grey	90	990
Shale, grey	70	1,060
Shale, dark	224	1,284
Shale, grey	67	1,351
Sand	9	1,360
Shale	25	1,385
Rock and shale	22	1,407
Rock, hard	19	1,426
Shale	4	1,430
Rock, hard, and shale	20	1,450

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Colorado shale	Shale, dark, calcareous	330	1,940
	Shale, dark, less calcareous	855	2,795
Dakota and Lower Cretaceous.	Sand, grey	45	2,840
	Shale, grey	10	2,850
	Shale, grey and white	75	2,925
	Sand, white	30	2,955
	Shale, sandy	25	2,980
Jurassic.	Shale, light grey, limy	15	2,995
	Shale, hard, grey	5	3,000
	Shale, limy	100	3,100
Fossils.	Limestone streak	8	3,108
Fossils.	Shale, limy	17	3,125
	Shale, grey and brownish	20	3,145
Fossils.	Shale, fine, grey	10	3,155
	Streak, hard	10	3,165
	Rock, coarse, limy	15	3,180
Fossils.	Rock, sandy, or slate	10	3,190
Devono-Carboniferous.	Limestone, white	5	3,195
	Shale, red	5	3,200
	Shale, blue	60	3,260
	Limestone	15	3,275
	Shale, black	10	3,285
	Sand, dark	17	3,302

16. *Ralph, Saskatchewan.*

Sec. 22, tp. 7, range 3, W. 2nd mer.
Well drilled in 1918 by Saskatchewan Exploration and Development Company.
Elevation: 1,900 feet.
Driller's record and from core samples:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Drift.	Clay loam	30	30
	Gravel	2	32
	Clay	58·6	90·6
Bottom of Fort Union.	Sand	0·4	91·0
	Sand with concretions	1	92
Probably equivalent to Bearpaw of Alberta.	Green clay shale	150	262
	Dark shale	20	282
	Grey shale slightly sandy	20	302
	Grey shale	10	312
	Grey, soft clay with fine sand	1	313
	Grey shale (Dentalium)	3	316
	Grey shale, sandy	10	326
	Soft shale	56	382
	Sandy shale	25	407
	Grey shale	115	522
	Grey shale (Inoceramus)	20	542
	Grey shale, harder and with marine shells	97	639
	Sandy shale	1	640
	Grey shale	32	672
	Gritty shale	10	682
Marine sandy shales deposited at same time as Belly River series and equivalent to lower part of Pierre of northern Alberta.	Sandy shale and mud (a few fragments of shells probably brackish water)	200	882
	Softer shale, less gritty	128	1,010
	Dark grey shale (Inoceramus fragments)	30	1,040
	Dark grey shale (fish scales)	22	1,062
	Grey shale	20	1,082
	Dark grey shale (marine shells)	20	1,102
	Soft grey shale	20	1,122
	Soft grey shale	18	1,140
	Dark, hard shale slightly gritty	22	1,162
	Grey shale slightly gritty (Dentalium, Inoceramus, etc.)	60	1,222
	Light grey, sandy shale	80	1,302
	Dark shale	15	1,317
	Hard, light shale	11	1,328
	Grey shale with marine fossils (Serpula, Inoceramus, Anchura, Syncyclonema sp.)	82	1,410
	Grey shale, gritty small specks of plant remains (Yoldia sp.)	78	1,488
	Grey shale, gritty	20	1,508
Niobrara	Calcareous shale	5	1,513

17. *Langham.*

Six miles below the Elbow.
Well drilled for the Canadian Northern railway by E. Coste in 1906.
Note supplied by J. B. Tyrrell.
Elevation: 1,400 feet, 1,345 feet to top of Dakota sandstone; 1,600 feet to bottom of Dakota sandstone; a few feet into yellow limestone probably Devonian.
A second well was later drilled by the same company and is reported by Mr. C. S. Gayton of Gowganda, N.Y., to be on sec. 24, tp. 39, probably range 7, W. 3rd mer.
Depth of well 1,358 feet.
Soft clay from top to bottom.
Water, salt, obtained at 1,340 feet.

18. *Maple Creek.*

Sec. 15, tp. 11, range 26, W. 3rd mer.
Drilled by the Maple Creek Gas, Oil, and Coal Co., Ltd.
Elevation: 2,507 feet.

In December, 1909, the well had reached a depth of 1,860 feet. Coal occurred at 196 feet and a 7-foot seam at 292 feet. Gas was reached at 1,120 feet and at two other points between 1,120 and 1,500 feet.

19. *Medicine Hat.*

Section above river-level at Redcliff.[1]
Driller's record:

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet.
	Clay, boulder	43	43
	Clays, light, sandy, and shales	49	92
	Shales, clay, dark	66	158
	Impure coal....0·8 inches.		
	Parting....2·8 "		
	Impure coal....0·6 "		
	Parting....2·8 "		
	Impure coal....0·6 "	7	165
	Clay, hard, sandy	17	182
	Coal	0 8	
	Clay (ironstones), hard, sandy	9 4	192
Foremost beds.	*Coal*	4 8	
	Underclay	3 6	
	Clay, sandy, and clay shale	12 10	213
	Clay shale with oyster bed at top	16	229
	Coal	0 6	
	Shale	3 6	233
	Coal	5 3	
	Clay	3 0	
	Coal	2 6	
	Sand and clay	24 9	
	Coal	0 6	269
	Sand and clay	17	286
	Clay, dark, sandy	14	300
	Clay, light, sandy	5	305
	Water-level of Saskatchewan at old mine at Stair.		

[1]Mem. 93, "Southern plains of Alberta," p. 110.

19. *Medicine Hat.*

Section below river-level of Saskatchewan. Elevation: 2,128 feet.

Log of gas well Balmoral st. Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface	Gravel, river deposit	50	50
Bottom of Foremost beds should be about here.	Clay, blue	154	210
Pakowki shale.	Shell, harder	5	215
	Shale, blue or clay	125	340
	Shell, lime	8	348
	Shale, blue	167	515
	Shell, lime	4	519
	Shale, brown, little gas at 519 feet	201	720
	Shale, hard	185	905
Milk River sandstone.	(First gas at 905 feet; Second gas at 930 feet). Shale, sandy, and sand (Main flow of gas at 980 feet, 2,500,000 cu. ft.)	85	990
Colorado shales.	Shale, dark	590	1,580
	Shell, lime, little gas	4	1,584
	Shale, dark	86	1,670
	Lime streaks, hard, and hard shale	90	1,760
	Shale, dark	190	1,950
	Hard and gritty	25	1,975
	Sandy, salt water, heavy flow	9	1,984
	Well plugged to 1,200 feet from surface.		

20. *Drowning Ford Ranch.*

NE. ¼ sec. 21, tp. 15, range 5, W. 4th mer. Driller's record:

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet and inches.
	Soil, dark	2	2
	Soil, sandy	26	28
	Gravel	23	51
	Shale, blue	36	87
	Rock, hard	2	89
	Shale, light	34	123
	Shale, dark	17	140
	Rock, hard	2	142
	Sand, fine, water and light flow of gas	12	160
	Clay, blue	32 6	192 6
	Rock, hard	2 2	194 8
	Shale, dark	70 4	265
	Rock, hard	0 6	265 6
	Shale, dark	22 6	287 0
	Sandstone	0 2	287 2
	Rock, hard	0 10	288
	Shales, dark	28	316
	Sandstone	4	320
	Shale	4	324
	Shale, blue	10	334
	Shale, brown	203	537
	Shale and gas	91	628
	Sandstone	9	637
	Shale, blue	20	657
	Sandstone	5	662
	Shale, blue, and gas	6	668
	50,000 cu. ft. per 24 hours.		

21. *Fusilier.*

Sec. 23, tp. 34, range 28, W. 3rd mer.
North of Court, Sask.
Elevation: at Court 2,392 feet; at Fusilier 2,374 feet; at well—by barometer 100 feet above Fusilier—2,534 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Drift, morainic	Clay, yellow; water at 138 feet	138	138
	Sand, soft and caving	7	145
	Clay, blue, with some sand	145	290
Equivalent to	Clay, soft, blue	126	416
Belly River.	Shale, brown	29	445
	Some coal in samples 425–490 feet.		
Beds exposed on Saskatchewan near Pakan.	Clay, light blue	15	460
	Shale, brown	4	464
	Shale, sandy, brown	21	485
	At 478 feet a thin sand gave water that rose 100 feet.		
	Shale, sandy, brown	30	515
	Shale, sandy, brown, with blue shale mixed with the sand	25	540
	Shale, blue, and sand	48	588
	Shale, brown, with some sand	29	617
	Water, sand somewhat less than	1	618
	Clay, blue, very hard	99	717
	Sand	11	728
	Clay, blue, sticky	22	750
Probably equivalent to Grizzly Bear formation.	Shale, brown	3	753
	Shale, blue, sticky	10	763
	Shale, sandy, blue	12	775
	Clay and sand	4	779
Probably equivalent to Shandro.	Clay, sticky, blue	15	794
	Shale, blue	128	922
Probably equivalent to Ribstone Creek formation.	Sand (possibly carrying water)	1	923
	Shale, blue	11	934
	Shell, hard	2	936
Lower part of Pierre shale and Colorado shale.	Shales, blue, and hard shells	10	946
	Shale, light blue, soft	99	1,045
	Shale, blue	30	1,075
	Shale	147	1,222
	Shale, blue. Hard shell at 1,295 feet	73	1,295
	Shale, blue	280	1,575
	Shale, blue	122	1,697
	Shale, blue black	148	1,845
	Shale, grey black	145	1,990
	Shale, dark blue, black	25	2,015
	Shale, grey black	50	2,065
	Shale, blue black	70	2,135
	Shale, black, gritty	152	2,287
	Shale, black	183	2,470
	Shale, brownish	1	2,471
	Shale, dark (some gas at 2,473 feet)	12	2,483
	Shale, brown, sandy	16	2,499
	Shale, sandy, blue black	43	2,542
	Shale, blue black (some gas)	18	2,560
	Shale, blue black, sandy	24	2,584
	Shale, sandy, ironstone nodules	41	2,625
	Sand, streaks, in shales	17	2,642

21. *Fusilier*—Continued.

Probable formation.	Material	Thickness in feet.	Depth from surface in feet.
Dakota? and possibly Lower Cretaceous.	Sand, fine, brown and white with streaks of grey shale	74	2,710
	Sandstone, streaks of, grey, in shales	46	2,702
	Coal, soft, black, shows of, and ironstones	4	2,766
	Sandstone, very hard, with streaks of shale	48	2,814
	Sandstones, fine, and shales, some coal in samples. Streaks of limestone with pyrites	10	2,824

22. *Sweet Grass.*

Sec. 1, tp. 1, range 12, W. 4th mer.
Drilled by the Grand Trunk Pacific Development Company.
Elevation: approximately 3,660 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Milk River sandstones	Sandstone and sandy clay	295	295
Colorado 1,745 feet.	Shale, blue grey	325	620
	Shale, blue grey, with some lighter sand	60	680
	Shale, blue grey	670	1,350
	Shale and white bentonite	260	1,610
	Shale with some sand	90	1,700
	Shale, blue grey	340	2,040
Dakota and Lower Cretaceous 535 feet.	Sand, light greenish and grey	90	2,130
	Shale, green and red	50	2,180
	Sandstones, grey and green, and shales	230	2,410
	Shale, green and brown	20	2,430
	Sandstones	55	2,485
	Shale, light green, sandy	80	2,565
	Sandstone, greenish grey, coarse	10	2,575
Jurassic 195 feet.	Shales	165	2,740
	Shale, blue black, calcareous	10	2,750
	Shale, green grey	20	2,770
Permo-Triassic 30 feet.	Sandstone, light grey, brown, calcareous	10	2,780
	Shale, grey brown, and sand, calcareous	10	2,790
	Sand, green tinted	10	2,800
Carboniferous.	Limestone, white	100	2,900

Toole County, Montana.[1]

Sec. 4, tp. 37 N., range 2 E.
A few yards south of the International Boundary.
Elevation: 3,075 feet (barometric).
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Glacial drift.	Drift, glacial	65	65
Virgelle sandstone (Milk River sandstone of Alberta).	Sandstone, light coloured	245	310
Colorado shale.	Shale, black and dark-coloured (Water)	970	1,280
	Shales, dark-coloured	310	1,590
	Sandstones, grey (Water)	50	1,640
	Shale, black, sandy	20	1,665
	Sandstone, grey (Gas)	70	1,735
	Shale, dark, sandy	25	1,760
	Shale, black, sandy	45	1,805
	Sand, grey (salt water)	5	1,810
	Shale, black, sandy	10	1,820
	Conglomerate	20	1,840
	Sandstone, grey	40	1,880
	Shales, black	180	2,060
Kootenay formation (Dakota of Canadian geologists).	Shales, bluish	70	2,130
	Shale, red	68	2,198
	Shale, grey	132	2,330
	Shale, black	20	2,350
	Shales, brown	150	2,500
	Sandstone strata (Gas and water)	170	2,670

A second hole was put down about a quarter of a mile southeast of the well just described and passed through the same strata. According to C. H. Jennings, who superintended the drilling of this well, shows of oil were encountered at about 960 and 1,660 feet, and small flows of gas at 1,300, 1,535, and 1,810 feet.

23. *Etzikom.*

SW. ¼ sec. 31, tp. 5, range 10, W. 4th mer., Lot of United Oil Wells No. 3, Etzikom coulee.
Elevation: about 2,825 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Surface deposits, brown clay	130	130
Foremost beds 120 feet.	Sand, fine, greenish grey	50	180
	Shale, dark greenish	20	200
	Sand, dark green	50	250
Pakowki shales 265 feet.	Shale, greenish	67	317
	Sand, greenish black	33	350
	Shale, greenish black	50	400
	Shale, soft, greenish black	115	515

[1] Bull. 641-C, U. S. Geol. Surv., p. 89.

23. *Etzikom*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface, in feet.
Milk River sandstones 170 feet.	*Coal*	5	520
	Shale, soft	6	526
	Coal and black shale	6	532
	Sand with streaks of *coal*	11	543
	Sand, fine, top of water-bearing beds. (Flow at surface 10,000 gals. per day, water fresh)	7	550
	Sand, fine, bottom of water-bearing beds	75	625
	Sand, fine, light grey	60	685
Colorado shales 1,770 feet.	Shale, blue black	65	750
	Shale, dark greenish	20	770
	Shale, blue black	350	1,120
	Shale, blue black	500	1,620
	Shale, blue black	43	1,663
	Sand, grey (gas 50,000 feet)	2	1,665
	Shale, blue black	275	1,940
	Sand, fine, steel grey (salt water)	2	1,942
	Shale, blue black	38	1,980
	Sand, fine, close	20	2,000
	Shale, soft (Bentonite)	15	2,015
	Sand (gas 10,000,000 cu. ft.)	5	2,020
	Shale, sandy	10	2,030
	Shale, blue	40	2,070
	Pebbles	15	2,085
	Sand	25	2,110
	Sand, black	20	2,130
	Shale, sandy	30	2,160
	Shale, black	40	2,200
	Shale, sandy (At 2,250 feet salt water, 7,000 bls. per day)	100	2,300
	Shale, black	30	2,330
	Shale, bluish	15	2,345
	Shale and grey sand	5	2,350
	Shale, blue grey	10	2,360
	Shale, greenish	10	2,370
	Shale and sand, blue grey	5	2,375
	Shale, blue grey	5	2,380
	Shale and sand	5	2,385
	Shale, dark grey	10	2,395
	Shale and sand	15	2,410
	Shale, dark grey	10	2,420
	Shale and sand	15	2,435
	Shale, dark grey	26	2,461
Dakota and Kootenay 749 feet.	Sand, grey	9	2,470
	Shale, grey	15	2,485
	Shale, green and red	15	2,500
	Sand with red stains	5	2,505
	Shale, brick red	15	2,520
	Shale, green and red	15	2,535
	Sand, light grey	25	2,560
	Shale, greyish white	155	2,715
	Sand, fine, compact, grey	25	2,740
	Shale, hard	10	2,750
	Shale, pink-coloured	150	2,900
	Slate, black (shale)	10	2,910
	Sand, fine yellowish (salt water)	20	2,930
	Shale, grey	45	2,975
	Sand	10	2,985
	Sand *saturated with heavy oil*	65	3,050
	Sand, generally grey	145	3,195
	Shale, blue grey	15	3,210
Palæozoic.	Limestone, grey, cream, and buff	410	3,620
	Shale, greenish grey	85	3,705

The upper part of the Colorado of No. 23, that is from about 685 to 1,060 feet, is calcareous and on that account has been classified locally as Niobrara.

24. *Foremost.*

Sec. 20, tp. 6, range 11, W. 4th mer.
Artesian well at station.
Elevation: 2,022 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Foremost beds. (A coal seam at the top has been denuded.) 359 feet.	Clay, yellow, and stones	71	71
	Clay, blue, and shale	8	79
	Clay and stones	11	90
	Shale	8	98
	Sandstone	13	111
	Rock	2	113
	Clay and stones	4	117
	Rock	1	118
	Shale, blue sand, and *coal*	24	132
	Coal and hard shale	12	144
	Shale, *coal*, and blue sand	2	146
	Shale and *coal*	14	160
	Shale and sandstone	19	179
	Shale, sandstone, and *coal*	17	196
	Shale	66	262
	Shale, sandy	97	359
Pakowki shale 266 feet.	Hard-pan	2	361
	Shale, sandy	80	441
	Hard-pan	1	442
	Shale	183	625
Milk River sandstone	Sand (water at 625 feet)	135	760

25. *Bow Island.*

SW. ¼, NW. ¼ sec. 4, tp. 11, range 11, W. 4th mer.
Gas well owned by municipality of Bow Island.
Approximate elevation: 2,526 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Recent and Glacial.	Surface deposits	55	55
	No samples	215	270
	Gravel	5	275
Foremost beds in part probably all marine shale.	Shale, grey, brown sandstone, and ironstones	25	300
	Shale with some coal	10	310
Pakowki shales.	Sandstone and clay shales	60	370
	Shales, sandy, brown	30	400
	Shale, brown	230	630
Milk River sandstones.	Shale, grey, sandy. (Probably sandstones with shale partings.)	110	740
Colorado shale.	Shales, blue-black and brownish-black	1,210	1,950
	Shale, grey, gritty	5	1,955
	No samples	192	2,147
	Gas horizon (sandstone)	—	2,147

The lower part of this section is given in more detail in the following log of the first well drilled in this district by the Canadian Pacific railway near the Saskatchewan river, the difference of elevation, 251 feet, may be used as the equation of comparison.

Sec. 15, tp. 11, range 11, W. 4th mer.
Canadian Pacific gas well, Bow Island.
Elevation: 2,275 feet.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Drift.	Clay and gravel	54	54
Pakowki shales, Milk River sandstones, and Colorado shales equivalent to beds in Bow Island well to depth of 1,251 feet.	Shales, grey and brown, with shells of limestone and sandstone from a few inches to 2 feet thick. (Struck 15,000 feet gas at 670 feet, and 15,000 feet at 1,100 feet.)	1,046	1,100
Colorado shales and sandstones.	Shale, dark brown, with thin sandstone shells	255	1,355
	Sandstone shells, very hard	20	1,375
	Shales, brown	125	1,500
	Shale, green, sandy	12	1,512
	Sandstone, hard, grey. (15,000 feet of gas at 1,525 feet.)	13	1,525
	Shale, green, sandy	75	1,600
	Shale, soft, brown with gypsum in first 50 feet and with grey sandstone shells every few feet from a few inches to 3 feet thick	200	1,800
	Shale, dark brown, with sandstone shells close together about half sandstone and half shale	66	1,866
	Sandstone, hard	20	1,886
	Shale, soft, dark	10	1,896
	Sandstone, grey, gas sand	19	1,915
	Shale, dark	1	1,916

Struck 110,000 feet of gas at 1,884 feet.

Struck gas in great quantity from 1,898 to 1,915 feet; at 1,908 feet the well measured 4,400,000 feet (Orton's table). On February 17, measured well after blowing one month, showed, 4,000,000 feet (Orton's table); drilled again and at 1,915 feet the well measured 7,000,000 feet. Closed well in 4-inch tubing with Dresser packer in 8-inch pipe. On February 23, rock pressure showed 750 pounds. On March 17, rock pressure was 800 pounds.

26. *Alderson (formerly Langevin).*

Sec. 30, tp. 15, range 10, W. 4th mer.

[1]The log here given is taken from the results of two borings, the first, 1,155 feet being from one and the remaining 271 feet from the other. The terms employed are chiefly those of the borer's log.

Elevation: 2,471 feet.

Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface deposits.	Clay loam	30	30
	Quicksand	7	37
	Clay	12	49
	Quicksand	10	59
	Clay and sand	9	68
	Quicksand	7	75
	Clays	8	83
	Quicksand	5	88
Pale beds of Belly River.	Sandstone	16	104
	Soapstone (grey, fine-grained clay)	9	113
	Lime rock (fine, calcareous sandstone) (small supply of water)	5	118
	Hard-pan (dark shale)	8	126
	Sand, coarse	7	133
	Soapstone (greyish clay)	60	193
	Rock, lime (fine calcareous sandstone)	7	200
	Sandstone	9	209
Foremost beds.	Small *coal* seam	—	—
	Soapstone	18	227
	Sandstone	5	232
	Clay, white	39	271
	Soapstone	50	321
	Rock, lime	5	326
	Soapstone, loose, shaly	137	463
	Clay, brown, ferruginous	5	468
	Rock, lime, dark	5	473
	Small *coal* seam	—	—
	Soapstone	50	523
	Gravel (small supply of water)	7	530
	Sandstone	6	536
	Rock, lime	4	540
	Sandstone	7	547
Pakowki shales.	Hard-pan (dark shale)	10	557
	Clays	35	592
	Soapstone, loose, shaly (fine grey clay)	350	942
	Rock, lime (fine, calcareous sandstone)	8	950
	Soapstone, hard	90	1,040
Milk River sandstones.	Sand and soapstone, with bands of hard-pan and supply of gas	20	1,060
	Sandstone, with streaks of hard gravel	50	1,110
	Gravel and clay	40	1,150
	Lime, hard. Great flow of gas	5	1,155
Colorado shales.	Shales and "lime rock" (probably calcareous limestone with layers of very dark, soft shale in second hole, to bottom)	271	1,426

[1]Dawson. On certain borings in Manitoba and the North West Territory. Roy. Soc. Can., vol. IV (1886), sec. IV, p. 95.

27. *Kevin, Toole County, Montana.*[1]

NW. ¼ sec. 25, tp. 34 N., range 4 W.

"A boring in search of oil was made about 8 miles southwest of Kevin, Toole county, on the James Miller ranch. It went to a depth of 1,755 feet, passing through part of the Colorado shale and all of the Kootenai formation, and probably entering the Jurassic. This well is in the midst of a large area of horizontal rocks, as shown by exposures in the vicinity and also by the lay of the Virgelle sandstone in the prominent escarpment to the west and north. This well was, therefore, drilled in an unfavourable structure position. Small flows of gas, however, were encountered at three horizons. The log of the well, furnished by H. C. Price, of Great Falls, Mont., is as follows:"

Log of well at the James Miller ranch.
Elevation: 3,360 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Glacial drift.	Loam and gravel	40	40
Colorado shale.	Black shale	120	160
	Shell, lime	2	162
	Shale, black	153	315
	Sand (Gas and water)	5	320
	Shale, grey black	100	420
	Sand (Gas)	10	430
	Shale, sandy	30	460
	Shale, hard, dark	10	470
	Shale, black	180	650
	Shale, grey, sandy	70	720
	Sand, black	10	730
	Shale, sandy	40	770
	Shale, light	80	850
	Shale, sandy	100	950
	Shale, black	90	1,045
	Sand, grey	20	1,065
	Sand (Gas, best flow)	5	1,070
	Shale, black	30	1,100
Kootenai formation (Dakota and Kootenay of Canadian geologists.)	Shale, light	15	1,115
	Rock, red	35	1,150
	Shale, light	45	1,195
	Shell, hard	5	1,200
	Sand, hard	25	1,225
	Shell	5	1,230
	Sand	70	1,300
	Shale, light	60	1,360
	Sand	30	1,390
	Shell, hard	10	1,400
	Shale, light	60	1,460
	Sand, hard	40	1,500
	Shell, hard	10	1,510
	Sand, hard	40	1,550
	Shale, yellow	50	1,600
	Sand, gritty	50	1,650
	Shell, hard	5	1,655
	Shale, black	20	1,675
	Shell, hard	5	1,680
Jurassic.	Rock, lime	50	1,730
	Shale, black	25	1,755

[1]Stebinger, E., "Possibilities of oil and gas in north central Montana;" Bull. 641-C, U. S. Geol. Surv., p. 89.

28. *Taber.*

Sec. 32, tp. 9, range 10, W. 4th mer.
Elevation: 2,671 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet and inches.
Surface deposits, 51 feet.	Clay, sandy, and small boulders	41	41
	Gravel and small boulders	10	51
Pale beds, 20 feet.	Shale and sandstone	20	71
Foremost beds 325 ft. 10 in.	*Taber coal seam.*		
	Shale and bands of limestone	24	95
	Shale, dark	9	104
	Sandstone	2	106
	Shale	3	109
	Sandstone, shaly	2	111
	Shale	14	125
	Sandstone	5	130
	Limestone, mixed, and sandstone	5	135
	Shale, dark	10	145
	Sandstone	4	149
	Shale	11	160
	Sandstone, mixed, and shale	24	184
	Shale	6	190
	Sandstone	5	195
	Shale	19	214
	Sandstone	57	271
	Shale	2	273
	Shale, dark	3	276
	Shale, sandy	32	308
	Shale, mixed, and sandstone	12	320
	Shale, black	10	330
	Shale, mixed, and sandstone	7	337
	Shale	36 6	373 6
	Coal, shaly	0 6	374
	Shale	2 4	376 4
	Coal	0 8	377
	Shale, dark	1	378
	Sandstone and shale	17	395
	Slate, black, mixed, and coal	1 10	396 10
Pakowki shales 211 feet.	Shale	8 2	405
	Limestone	0 6	405 6
	Sandstone	5 6	411
	Shale	180	591
	Shale, sandy	11	602
	Conglomerate	2	604
	Shale, sandy	4	608
Milk River sandstones 202 feet.	Sandstone	19	627
	Coal	0 2	627 2
	Fireclay	0 1	627 3
	Shale, dark	7 9	635
	Sandstone	7	642
	Shale	4	646
	Shale, sandy	12	658
	Sandstone (Water)	12	670
	Fireclay	3	673
	Coal	0 3	673 3
	Sandstone	79 9	744
	Shale, light	0 6	744 6
	Sandstone	65 0	810

28. *Taber*—Continued.

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet and inches.
Colorado shale and sandstone.	Sandstone, mixed, and shale	28	838
	Shale	67	905
	Shale with sandstone partings	25	930
	Shale, probably, no record	530	1,460
	Shale, black	460	1,920
	Beds, grey, sandy, some black shales	40	1,960
	Shales, black	120	2,080
	Sandstone, white	10	2,090
	Shales, sandy	50	2,140
	Limestone, fine-grained, white	10	2,150
	Shale, black	50	2,200
	Sandstone	20	2,220
	Conglomerate, grey	20	2,240
	Sandstone, white, with some dark partings	110	2,350

29. *Brooks.*

SE. ¼ sec. 33, tp. 18, range 14, W. 4th mer.
Owner, Canadian Pacific Railway Company.
Elevation: 2,487 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Pale beds of Belly River.	Surface material	5	5
	Sand and sandstone	13	18
	Clay, grey, some sand	118	136
	Sandstone, whitish, plant remains	20	156
	Clay, whitish, sandy	10	166
	Clay, yellow, sandy	20	186
	Sand, grey	9	195
	Clay, sandy	35	230
	Clay, yellow, greyish	17	247
	Sand	78	325
	Stone, hard layer, greenish grey	25	350
	Sand, fine	30	380
	Sand, coarse	11	391
	Sand and clay, traces of coal	58	449
	Shale, brown	11	460
Foremost beds.	Shale, sand, and traces of coal	31	491
	About half samples are of *coal*	20	511
	Shale, brown, some coal	20	531
	Shale, brown	9	540
	Sand, grey, and shale	20	560
	Shale, grey and brown	40	600
	Shale, dark, hard, sandy	100	700
	Shale, grey	10	710
	Shale, brown	130	840
	Coal, mostly, in samples	10	850
Pakowki shales.	Shale, brown	15	865
	Shale, clay, ironstone	15	880
	Clay, sandy, grey	30	910
	Shale, grey	210	1,120

29. *Brooks*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Milk River sandstones.	Beds, sandy, dark, with traces of coal.....	330	1,450
	Ironstones, clay, dark grey.....	40	1,490
	Shale, hard, sandy.....	45	1,535
	Beds, fine, sandy.....	5	1,540
	Fragments, coarse.....	60	1,600
	Sand, fine, dark.....	10	1,610
	Shale, grey, sandy.....	15	1,625
Colorado shales.	Sand, fine, dark.....	5	1,630
	Shale, dark grey.....	95	1,725
	Sand, fine.....	5	1,730
	Shales, sandy.....	45	1,775
	Shale, black.....	635	2,410
	Shales, black, some sand.....	175	2,585
	Sand, fine, black.....	10	2,595
	Sandstone at bottom of well.....		

A flow of about 20,000 cubic feet of gas per day.

30. *Cassils.*

Sec. 5, tp. 19, range 15, W. 4th mer.
Elevation: 2,493 feet.
There is some uncertainty about this log. The first three beds probably represent drift, and layers 4 to 8 inclusive appear to represent the Pierre. Gas was struck in layer 14.[1]
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Drift, 52 feet.	1. Loam, clay, dark.....	2	2
	2. Clay, yellow.....	10	12
	3. Clay, blue.....	40	52
Pierre 242 feet.	4. Shale, blue.....	110	162
	5. Shale, grey.....	38	200
	6. Rock, sand, drab.....	3	203
	7. Shale, blue.....	85	288
	8. Shale, brown.....	6	294
Belly River 706 feet.	9. Coal.....	2	296
	10. Shale, grey.....	134	430
	11. Rock, sand, brown.....	3	433
	12. Shale, black.....	257	690
	13. Shale, grey.....	135	825
	14. Rock, sand, brown (Gas).....	5	830
	15. Shale, blue.....	85	915
	16. Shale, grey, sandy.....	40	955
	17. Shale, grey.....	45	1,000

Dawson says layers 9 to 17 are probably Belly River, though the "black shale" of No. 12 is anomalous.

[1]Dawson, Roy. Soc., Can., IV (1886), IV, 98.

31. *Castor.*

Elevation: at station, 2,680 feet. Driller's record.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Surface deposits	22	22
Edmonton.	Sandstone	55	77
Bearpaw shale or upper Pierre.	Clay, blue, small amount of sand	58	135
	Clay, blue	140	275
	Limestone, hard (Bulwark beds)	10	285
	Clay, blue, a little water here	215	500
	Clay, blue, a little gas here	100	600
	Clay, blue, and some brown shale	70	670
Pale beds, Belly River.	Sandstone and sand, gas here	4	674
	Clay, blue, with layers of brown shale	226	900
	Sand and large flow of water	40	940
	Clay, blue, and shale	20	960
	Limestone, very hard	15	975
Foremost beds, Belly River.	Clay, blue, and shale	183	1,158
	Coal, soft	2	1,160
	Shale, soft, brown	40	1,200
	Clay, blue, and shale	192	1,392
	Gas sand, gas 300 lbs. per sq. in	38	1,430
	Clay, hard, blue	3	1,433
	Water sand, water 20 bls. per hour	22	1,455

32. *Hawkins.*

In 1914 and 1915 the Gratton Creek Oil Company drilled a hole on sec. 4, tp. 45, range 8, W. 4th mer., to a depth of 1,629 feet. The log of this well was supplied by Mr. Charles Taylor of Edmonton.

Elevation: 1,938 feet. Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Lower part of Belly River.	Drift	25	25
	Clay, soft, grey, sandy	82	107
	Sandstone, blue, and fossils	2	109
	Shale, grey, bands of blue sandstone—shells	25	134
	Shales, dark; *coal seams*	6	140
	Shales, bluish grey	35	175
	Shales, dark, *coal*	2	177
	Sandstone shells, blue	15	192
	Clay, brown	8	200
	Sandstone, light grey, carbonaceous	10	210
	Sandstone, light grey, with clay	5	215
	Shale, dark grey	15	230
	Shale, grey	70	300
	Sand, grey	42	342
Division between lower Pierre and Colorado at about 800 feet.	Shale, grey, a 2-foot hard shell	35	377
	Shale, grey	143	520
	Shell, hard	2	522
	Shale, grey	30	552
	Shell, hard	2	554
	Shale, grey, with hard shells at 645, 750, 850, 960 feet; oil at 1,215 feet	791	1,345
	Shell, lime	8	1,353
	Shell, grey	52	1,405
	Shell, hard	5	1,410
	Shale, grey, oil at 1,582 feet	172	1,582
	Shale, grey	38	1,620

Gas at 192 feet. Water at 270 feet. Water and oil at 300 feet. Oil at 1,215 and 1,582 feet. Gas 500,000 cubic feet per day, 500 lbs. pressure at 1,620 feet.

33. *Viking.*

NW. ¼ sec. 24, tp. 48, range 13, W. 4th mer.
Elevation: 2,284·9 feet.
From examination of samples by J. S. Stewart.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Drift.	Clay, light grey	85	85
Equivalent to Pale and Foremost beds, Belly River.	Shale, clay, light grey	35	120
	Shale, light grey, somewhat sandy	20	140
	Shale, very fine, sandy	25	165
	Shale, fine, sandy, light grey to brown	05	170
	Shale, light grey, and fragments of *coal*	40	210
	Shale, dark grey, carbonaceous	33	243
	Coal	02	245
	Shale, dark grey, carbonaceous	07	252
	Sandstone, white, fine-grained	20	272
	Shale, clay, light grey, sandy	08	280
	Shale, clay, dark grey	60	340
	Shale, dark grey, specks of *coal*	20	360
	Shale, clay, grey, contains shells	10	370
	Shale, clay, grey	25	395
	Clay, grey, greenish, light grey, sandstone	70	465
	Sandstone, fine-grained, contains carbonaceous matter	20	485
	Shale, grey, chocolate coloured	30	515
	Shale, dark grey, carbonaceous	15	530
	Shale, dark grey, with some coal	05	535
Equivalent to lower part of Foremost beds of Belly River.	Shale, dark grey, and carbonaceous shale with shells probably. In No. 6 well a coal seam was struck at 678-680 feet, equivalent to 648-650 feet in No. 1 approximately.	120	655
	Shale, chocolate brown	35	690
	Sandstone, light grey, comparatively coarse, gave flow of water	50	740
Lower Pierre shale.	Shale, blue grey	145	885
	Shale, blue grey, sandy in places	5	890
	Shale, brown, carbonaceous	5	895
	From driller's record, no sample kept:		
	Brown shale	315	1,210
	Lime shell, hard	5	1,215
	Shale, blue	185	1,400
	Shale, brown	205	1,605
	Sand with grey clay in No. 6 at 1,652-1,682 feet	5	1,610
Colorado shale	Shale, dark grey, rusty	250	1,860
	Upper gas sand at 2,180 feet.		
	Shale, dark grey, typical Benton shale	342	2,202
	Shale, rusty, dark grey	138	2,340
	Lower gas sand at 2,335 feet.		

Good water struck at 120 feet.
Salt water at 690 feet.
Gas flow at 2,340 feet.

34. *Vegreville.*

Sec. 18, tp. 52, range 14, W. 4th mer.
Elevation: 2,082 feet.

The first attempt at finding gas in the monocline crossing Battle river was made at Vegreville station, on the Canadian National railways, in 1912 and 1913. A small showing of gas was obtained, but when the well reached a depth of 2,000 feet the attempt was abandoned and the casing pulled. The well was finished April 6, 1913. As the department was not supplied with samples from the well no advice as to the horizon reached could be given. J. S. Stewart of this department obtained permission to examine the samples that were preserved and the following log has been condensed from his notes.

Specks of coal were recorded in a great number of the samples and it has since been learned that the samples were frequently taken in a bucket also used to carry coal, so that the log already published (Summary Report for 1916) contains some very doubtful references to specks of coal in the samples. These are omitted from the log below.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	No record	20	20
	Clay shale—slate grey, very fine-grained, small quartz grains, few specks carbonaceous matter	5	25
	Sand, fine-grained, light yellow, iron-stained, quartz, carbonaceous matter	5	30
Probably represents most of the Pale and Foremost beds.	Mud and sand, some coarse sand, brownish grey, calcareous	5	35
	Sand and mud, quartz grains as large as ¼ inch in diameter, dark grey	15	50
	Sand, light grey, contains small grains of resin ¼ inch in diameter, fine-grained	5	55
	Clay, grey, calcareous, small flakes of mica, carbonaceous matter	25	80
	Sand, light grey, very calcareous, contains pebbles as large as ¼ inch	50	130
	Clay or shale, grey, slightly calcareous, fine-grained, contains small specks of resin:	15	155
	Shale, grey, contains small grains of *coal*, a thin coal bed here, very calcareous, slightly sandy	10	165
	Sandstone, very calcareous, quite porous, coarse-grained	10	175
	Shale, grey, contains a little lime, darker at bottom and contains a *thin bed of coal*	10	185
	Sandstone, light grey, contains a little lime, slightly calcareous, medium-grained	5	190
	Shale, light chocolate brown and grey, slightly carbonaceous	10	200
	Coal dirty, bed at least 6 feet	5	205
	Shale, brownish grey, concretionary	35	240
	Sandstone and shale, sandstone very light grey, shale, dark grey	15	255
	Shale, dark grey, slightly sandy	60	315
	Shale, light grey, contains some concretionary material and some carbonaceous shale.	10	325
	Shale and sand, gas at 328 feet (2 to 5 feet sand), shale, light grey, contains some carbonaceous shale	15	340
	Shale, dark grey, carbonaceous	15	355
	Shale, dark grey, contains a little carbonaceous shale	10	365

34. *Vegreville*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Shale, light grey, sandy, contains a thin sandstone, a little coal at 380 feet	20	385
	Sandstone, light grey, contains a little carbonaceous matter	5	390
	Shale, chocolate brown, contains a little sandstone and carbonaceous shale	120	510
	Shale, grey, and sandstone	5	515
	Shale, light brown, and sandstone comparatively coarse, gas reported	5	520
	Shale, bluish grey, contains a little carbonaceous shale	40	560
	Shale, pronounced brown	5	565
	Shale, blue grey, very fine-grained	5	570
	Shale, brown, sandy	5	575
	Shale, blue grey	10	585
	Shale, brown	30	615
Probably marine shales equivalent to Pakowki shale.	Shale, light blue grey	415	1,030
	Shale, blue grey	195	1,225
	Shale, dark blue, very carbonaceous	25	1,250
	Shale, light blue	35	1,285
Trace of Milk River beds.	Shales, light blue, sandy, and some carbonaceous matter, contains shells	35	1,320
	Shale, light blue, contains a little white sandy shale and carbonaceous shale	35	1,355
	Shale, blue, slightly sandy, gas about 225,000 feet, reported at 1,360 feet	10	1,365
Colorado shales and sandstones.	Shale, blue	110	1,475
	Strata below this probably Benton in age.		
	Shale, dark grey to black fissile	90	1,565
	Shale, dark grey to black, a little gas reported here	5	1,570
	Shale, calcareous, dark grey to black in colour	130	1,700
	Shale, dark grey to black, not as fissile as above	45	1,745
	Shale, dark grey to black	115	1,860
	Shale, light brown, sandy	5	1,865
	Sandstone, brown, very fine-grained, a small flow of gas from 2-foot bed of sand. Bottom of sand reported at 1,872 feet	10	1,875
	Shale, dark grey to black, fissile, iron-stained	125	2,000

The major part of the gas came from 1,360-foot sand—very little gas from the 1,870-foot sand. Total flow reported to have been about 225,000 feet.

35. *Victoria.*

Sec. 12, tp. 58, range 17, W. 4th mer.
Well drilled by Geological Survey, 1899.
Elevation: about 1,850 feet.
Driller's record.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Lower part of sandstones at Victoria.	Sand	10	10
	Shale, light grey, with traces of sand	10	20
	Shale, grey, sandy	10	30
	Shale, light grey, sandy	20	50
Mostly marine shales comparable to upper La Biche, lower Pierre in age.	Shale, light grey, no sand	50	100
	Shale, grey, darker in colour	10	110
	Shale, grey, lighter	10	120
	Shale, grey, brownish	10	130
	Ironstone layer	1	131
	Shale, light grey	9	140
	Shale, light brownish-grey, quite hard. (At 156 feet struck a small vein of gas)	40	180
	Shale, dark-brownish, with streaks of ironstone	80	260
	Shale, dark brown. Strata of sandstone	10	270
	Shale, grey. Ironstone stratum	10	280
	Shale, grey, with 3-foot ironstone stratum	10	290
	Shale, hard, brownish grey	10	300
	Shale, hard, grey	10	310
	Shale, softer, dark grey	30	340
	Shale, harder, dark grey	10	350
	Shale, hard, brownish grey	40	390
	Shale, hard, light grey, with 2 feet of ironstone	20	410
	Shale, brown	10	420
	Shale, brownish grey	50	470
	Shale, very hard, grey	10	480
	Shale, light brownish grey. At 495 feet water, slightly saline, and gas	20	500
	Ironstone stratum	8	508
	Shale, light brownish grey	12	520
	Shale, grey, losing brown tone	10	530
	Ironstone stratum	5	535
	Shale, hard, light grey	5	540
	Shale, grey, with stratum of ironstone	10	550
	Shale, bluish grey	4	554
	Shale, dark bluish grey	6	560
	Shale, dark bluish grey, with ironstone stratum and fragments of pyrite	10	570
	Shale, grey, very soft	50	620
	Shale, very soft, grey, with 3 feet of sandstone or ironstone	10	630
	Shale, bluish grey, very soft	75	705
Lower La Biche shale (Colorado).	Shale, soft, dark	255	960
	Shale, soft, dark, with layers of sand and a little gas	10	970
	Shale, soft, dark	30	1,000
	Shale, soft, dark, with streaks of sandstone	20	1,020
	Shale, dark. Gas	10	1,030
	Shale, dark. Increased gas	60	1,090
	Shale, soft, black	140	1,230
	Shale, soft, black, with streaks of sandstone	20	1,250
	Shale, soft, black	70	1,320
	Shale, brown, with sandstone layers	20	1,340
	Shale, soft, dark	50	1,390

35. *Victoria*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Pelican sandstone.	Shale, bluish, with thin streaks of sandstone	20	1,410
	Shale, black	18	1,428
	Sandstone, hard	2	1,430
Pelican shale.	Shale, black	30	1,460
	Shale, bluish	40	1,500
Grand Rapids sandstone.	Shale, bluish, streaks of sandstone with gas	05	1,505
	Sandstone, hard	10	1,575
	Shale, dark, mixed with sandstone	10	1,585
	Sandstone, hard	15	1,600
	Shale and sandstone strata mixed	45	1,645
	Sandstone, hard	5	1,650
	Sandstone	15	1,665
	Shale, dark	4	1,669
	Sandstone, very hard	11	1,680
	[1]Shale, dark blue, with strata of hard sandstone 1 to 4 feet thick	90	1,770
Clearwater shale.	Shale, dark blue	70	1,870

Regarding the results obtained at Victoria[2] Dawson writes:

"In the section on the Athabaska, including the borings at Athabaska Landing and Pelican river, the persistence of the Pelican and Grand Rapids sandstones renders it possible to fix equivalency of horizons with considerable accuracy, but neither of these sandstone intercalations occur in recognizable form at Victoria, and it does not appear to be possible to draw any line of demarcation until a depth of about 1,500 feet is reached, at which depth it seems probable that beds representing the Grand Rapids sandstones may be entered . . . . .

"From all the evidence now available, it would appear that the Victoria bore-hole penetrated to within about 250 feet of the top of the 'Tar-sands', should these occur here, this horizon being at a depth of about 2,100 feet from the surface. At Athabaska Landing the bore-hole probably reached to within a very few feet of the top of the 'Tar-sands,' which may there occur at a depth of 1,800 feet."

[1] Geol. Surv., Can., Sum. Rept., 1897, 1898, 1899.
[2] Geol. Surv., Can., Ann. Rept., vol. XII, p. 12A.

30. *Lethbridge.*

Elevation: 2,093 at Canadian Pacific railway station.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Surface deposits 299 feet.	Sand	12	
	Gravel	40	
	Hard-pan and gravel	138	
	Hard-pan	20	
	Sand and gravel	50	
	Soapstone	25	
	Gravel	5	299
Pale beds of Belly River formation 651 feet.	Shale	111	
	Sandstone	21	
	Soapstone and shale	46	
	Sandstone	30	
	Shale and sandstone	121	
	Shale	36	
	Soapstone and sandstone	10	
	Soapstone and shale	73	
	Shale, black	12	
	Soapstone	15	
	Shale, black	143	
	Sandstone	25	
	Limestone	15	950
Foremost subdivision brackish water 350 feet.	Shale, black	36	
	Limestone	6	
	Shale, black	158	
	Shale, grey	30	
	Shale, black	10	
	Sandstone	9	
	Shale, black	20	
	Shale, grey	9	
	Sandstone	9	
	Shale, black	54	
	Sandstone	9	1,300
Pakowki shale 215 feet.	Shale, dark	80	
	Shale, lighter	70	
	Shale, dark	60	
	Shale, hard, dark	5	1,515
Milk River sandstone 88 feet.	Sandstone	5	
	Shale, green, very hard	4	
	Shale, soft	32	
	Rock, sand. Water-bearing	47	1,603
Colorado formation.	Shale, greenish	100	
	Shale, dark	142	
	Shale, dark, with streaks of white	95	
	Shale, calcareous	125	
	Shale, dark	80	
	Shale, light grey	30	
	Shale, dark	45	2,220

37. *Kipp.*

Sec. 34, or 35, tp. 9, range 23, W. 4th mer.
Well drilled by the West Canadian Coal Mining Company at Kipp station. Well completed in June, 1910. Started 10 feet above water-level and 50 feet below the sandstone overlying the Bearpaw.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Silt, river	20	20
Bearpaw.	Clay	12	32
	Shale	64	96
	Sandstone	19	115
	Shale	14	129
	Shale, sandy	14	143
	Ironstone	1	144
	Shale	22	166
	Ironstone	1	167
	Shale	93	260
	Shale, sandy	305	565
Belly River.	Sandstone	27	592
	Coal	3	595
	Shale	5	600
	Shale, sandy	15	615
	Shale and sandstone	43	658

The 565 feet of the Bearpaw passed through in the well, together with the 50 feet above the top of the well, makes a total thickness of 615 feet for this series at this point.

A complete section of the Bearpaw shale is given in the following diamond drill record made near Scabby butte.

Sec. 9, tp. 11, range 22, W. 4th mer.

Probable formation.	Material.	Thickness in feet and inches.	Depth from surface in feet.
	Shale, dark, soft	27	
	Shale, dark, sandy	150	
	Shale, hard, tough	31	
	Shale, sandy	17	
	Sandstone, hard	2	
	Sandstone, soft, grey	30	
	Shale, soft, dark	19	
	Shale, hard, dark	18	
	Shale, dark, sandy	119	
	Shale, dark	93 2	
	Ironstone band	0 10	
	Shale, dark	70	
	Shale, dark, sandy	36	
	Ironstone band	0 10	
	Shale, dark, sandy	7 6	
	Shale, sandy	6 8	
		622	

Next underlying are the coal-bearing beds of the top of the Belly River series.

38. *Gleichen.*[1]

Sec. 13, tp. 23, range 22, W. 4th mer.
Elevation: 2,926 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Sand and clay	8	8
	Quicksand	20	28
	Clay, blue, with gravel and boulders	39	67
	Sand, black	11	78
	Clay, blue	22	100
	Gravel, cement	15	115
	Soapstone	40	155
	Sand, white, small flow of water	5	160
	Soapstone	91	251
	Sand, black	7	261
	Soapstone, loose	74	335
	Lime, white	3	338
	Shale, black	40	378
	Rock, putty	12	390
	Lime and loose shale	10	400
	Soapstone	35	435
	Rock, sand	9	444
	Shale, black	20	464
	Soapstone, gravel, with sand and water	38	502

39. *Calgary.*

Well No. 2 of the Calgary Natural Gas Company, on Col. Jas. Walker's land, East Calgary, near the Bow river.
Elevation: 3,415 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Edmonton formation.	Deposits, surface, gravel and boulders	54	54
	Sandstone	20	74
	Shale, soft, blue	37	111
	Sandstone, hard and fine	8	119
	Shale, soft, white	7	126
	Lime crystal, quartzite	11	137
	Shale, soft	6	143
	Slate, white	2	145
	Shell, sand, hard	2	147
	Shale, white	4	151
	Shell, sand	1	152
	Slate, white, hard	6	158
	Shell, lime, hard	2	160
	Slate, white, soft	18	178
	Shell, sand	2	180
	Shale, blue, soft	35	215
	Sand	13	228
	Slate, soft	24	252
	Sand, grey, hard and soft alternating	16	268
	Slate, white	7	275
	Sand	5	280
	Slate, soft	10	290
	Slate, grained	10	300
	Sand, grey, hard	35	335
	Slate, soft	5	340

[1] Dawson, Roy. Soc. Can., vol. IV, sec. IV, p. 99.

30. *Calgary*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Sand, hard	12	352
	Slate, dark, grained, lig. calm	8	360
	Sand, grey, hard, with pebble	70	430
	Slate, soft	2	432
	Sand, grey	8	450
	Slate, grey and black carrying traces of *coal*	57	507
	Sand, medium hard	5	512
	Slate, black	3	515
	Sand, black	15	530
	Slate, hard, brown	20	550
	Slate, white	25	575
	Sand, grey, fine	10	585
	Slate, white	5	590
	Sand, grey	6	596
	Slate, soft	1	597
	Sand, hard	13	610
	Sand, grey, soft	27	637
	Sand, grey, sharp	11	648
	Slate	12	660
	Sand and slate in alternating layers of 10 to 12 feet	78	738
	Slate	35	773
	Sand, grey, soft	19	792
	Slate, dark, soft	9	801
	Sand, dark grey	37	838
	Slate	5	843
	Shale, sand with pebble, conglomerate	15	858
	Slate	4	862
	Sand	13	875
	Sand, blue, hard	43	918
	Slate	10	928
	Sand	26	954
	Slate	2	956
	Sand	7	963
	Slate, black, grained	30	993
	Sand, blue, hard	20	1,013
	Slate	12	1,025
	Sand, blue, hard	63	1,088
	Slate	42	1,130
	Sand, dark grey	14	1,144
	Slate	3	1,147
	Sand, grey	34	1,181
	Slate	2	1,183
	Sand, dark grey and sharp	49	1,232
	Slate	4	1,236
	Sand, grey, fine, hard	7	1,243
	Shale	42	1,285
	Sand, fine, dark blue turning grey	103	1,388
	Shale, hard, grey turning to soft and black, then brown	80	1,468
	Sand	5	1,473
	Shale, brown	15	1,488
	Slate, white	74	1,562
	Limestone	36	1,598
	Sand, grey, sharp	75	1,673
	Slate, white turning to brown	93	1,766
	Sand, dark grey, fine	55	1,821
	Slate, grey	52	1,873
	Shale, brown	25	1,898
	Coal	13	1,911
	Sand, dark grey	42	1,953
	Shale, black, grained	17	1,970
	Sand, hard, fine	15	1,985
	Shale, brown	6	1,991

39. *Calgary*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Marine beds of the upper part of the Pierre are probably represented in part of this section, though most of it seems to be shore deposits.	Sand, black, hard	74	2,065
	Shale, brown	10	2,075
	Shell, sand	3	2,078
	Shale, brown	8	2,086
	Shell, sand	4	2,090
	Shale, brown	32	2,122
	Sand, dark grey	20	2,142
	Shale, brown	13	2,155
	Shell, very hard and flinty	2	2,157
	Shale, brown	10	2,167
	Sand, grey	5	2,172
	Shale, brown	7	2,179
	Shell, sand	2	2,181
	Shale, brown	11	2,192
	Shell, hard	5	2,197
	Sand, brown	5	2,202
	Shale, sandy brown, with some culm or bitumen	40	2,242
	Slate, white, and sand shells with pebble	10	2,252
	Sand, light grey then dark grey, hard and soft with pebble at bottom	110	2,362
	Shale, brown	12	2,374
	Shell, hard, brown	4	2,378
	Coal, semi-bituminous	1	2,379
	Shale, sandy	9	2,388
	Shale, brown	6	2,394
	Sand slate, black and shaly, calcareous matter with sand and dark brown pebble	16	2,410
	Sand with white quartz crystals	8	2,418
	Sand, grey, hard pebble, trace of culm	3	2,421
	Shale, sandy, with shells of bitumen	31	2,452
	Gypsum, calcareous	2	2,454
	Shale, sandy	4	2,458
	Shale, dark and soapy	25	2,483
	Slate, black, with sand shells	5	2,488
	Slate, black, flaky, with bituminous coal seams	14	2,502
	Shell, hard and flint-like	6	2,508
	Shale, black and flaky	4	2,512
	Slate, shaly	12	2,524
	Shell, flinty, hard	4	2,528
	Slate, shaly	5	2,533
	Shell, sandy	2	2,535
	Slate, shaly	9	2,544
	Shell, hard and gritty	3	2,547
	Slate, shale	7	2,554
	Shell, sandy	4	2,558
	Slate, shaly	2	2,560
Belly River beds.	*Coal*	5	2,565
	Shale, sandy, culm	4	2,569
	Shell, sandy	3	2,572
	Shale, sandy, pebbled	6	2,578
	Sand, with streaks of shale, a little gas	32	2,610
	Shale, black and sandy	13	2,623
	Shell, sand	3	2,626
	Shale, black, with some coal	10	2,636
	Sand shale, coal showing	8	2,644
	Sand, black and white, with pebble	12	2,656
	Coal shale or culm	2	2,658
	Coal seam	7	2,665
	Shale, sandy	1	2,666
	Sand, coarse then fine	16	2,682
	Slate	1	2,683
	Sand, grey then darker	19	2,702

39. *Calgary*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Shale, black and sandy	17	2,719
	Shell, sand	2	2,721
	Shale, black, sandy	18	2,739
	Sand, black and hard	3	2,742
	Sand, with shale	10	2,752
	Sand, fine, black, very hard	9	2,761
	Sand, coarse, *gas sand*	11	2,772
	Coal with tarry-like sand just above it	4	2,776
	Shell sand, blue, hard	3	2,779
	Slate, black	15	2,794
	Soapstone	1	2,795
	Sand, coarse, grey	5	2,800
	Coal, bituminous	1	2,801
	Slate, sandy	9	2,810
	Shale, brown	9	2,819
	Sand, coarse, grey	15	2,834
	Coal, bituminous	3	2,837
	Slate, dark brown	8	2,845
	Shell, sand	3	2,848
	Shale, dark brown, soft	20	2,868
	Coal, bituminous	4	2,872
	Slate shale, with soapstone	6	2,878
	Sand, coarse and grey	19	2,897
	Slate, black	1	2,898
	Sand, hard, black	6	2,904
	Coal, bituminous	3	2,907
	Slate shale, hard	42	2,949
	Coal, bituminous	3	2,952
	Shale, slate and coal	15	2,967
	Total depth of well	.....	3,414

There is a small production of gas from this well.

Analysis of Gas.

Carbon dioxide	0·0
Carbon monoxide	0·0
Oxygen	0·1
Heavy hydrocarbons	1·80
Hydrocarbons of marsh gas series	86·70
Hydrogen	5·40
Nitrogen	6·00
	100·00

40. *Ponoka.*

Sec. 4, tp. 43, range 25, W. 4th mer.
Elevation: 2,645 feet.

The Provincial government recently drilled a gas well on the grounds of the asylum at Ponoka. The well is now 2,350 feet deep and has 8-inch casing down to 2,139 feet. Gas was encountered at the following depths, given in feet: 853, 912, 1,106, 1,396, 1,524, 1,872, 1,930, 2,257, and 2,300.

Down to 1,935 feet the flows of gas are small and of no commercial importance. At 2,257 feet there was for a time an open flow of 100,000 cubic feet per day with rock pressure of 410 lbs., but this was reported as fast failing. According to the Geological Survey's small scale map

40. *Ponoka*—Continued.

Alberta the rocks at the surface of Ponoka are of the Paskapoo formation. A log of the well compiled by the Department of Public Works at Edmonton follows:

Probable formation	Material.	Thickness in feet.	Depth from surface in feet.
Paskapoo.	Sand (water at 75 and 125 feet)	137	137
	Clay, blue	21	158
	Shale	20	178
	Coal, 12 inches	1	179
	Shale	16	195
	Clay, blue	14	209
	Shale	91	300
	Coal, 25 inches thick	2	302
	Clay, blue	7	309
	Shale, brown	31	340
	Shale, lime	9	349
	Shale, black	41	390
	Sand, white (gas at 409 feet)	31	421
Edmonton formation.	Shale, black (5 inches coal at 433 feet)	29	450
	Shale, brown	10	460
	Coal, 8 feet thick	8	468
	Shale, brown	57	525
	Lime (not hard)	30	545
	Sand, hard (water at 548 feet)	25	560
	Sand, soft	5	565
	Clay, blue	35	600
	Lime	17	617
	Shale, black	25	642
	Sand, grey	9	651
	Shale, black and brown	54	715
	Lime, hard	12	727
	Sand, white	23	750
	Shales, black and brown	100	850
	Sand, white (gas at 853 feet)	5	855
	Shale, brown	12	867
	Lime, grey	11	878
	Rock, pink	22	900
	Sand, grey (gas at 912 feet)	15	915
Shales.	Shale, black	123	1,038
	Mud, black	20	1,058
	Shale, brown with sandstone partings; gas at 1,106 feet	80	1,138
	Sand	10	1,148
	Shales, black and brown	112	1,260
	Sand	10	1,270
	Shale, brown and black	110	1,380
Belly River formation.	Sand	20	1,400
	Shale, black and brown	62	1,462
	Sand, white	9	1,471
	Shale, blue black and brown	183	1,654
	Sand, white	146	1,800
	Shale, black	10	1,810
	Sand, white	52	1,862
	Shale, brown	18	1,880
	Shale, black	50	1,930
	Shale, grey, brown, and black	140	2,070
	Sand, white	16	2,086
	Shale, black	4	2,090
	Beds of black and brown shales, alternating, and white sands	167	2,257
	Main flow of gas at	.....	2,257

41. *Wetaskiwin.*

No. 1 City well near power-house.
Elevation: 2,402 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Paskapoo formation.	Soil	10	10
	Clay, blue	82	92
	Sandstone	1	93
	Shale, blue	27	120
	Sandstone	2	122
	Shale, blue	13	135
	Sandstone	½	135½
	Shale, blue	4½	140
	Sandstone	½	140½
	Shale, blue	23	163½
	Sandstone	1½	165
	Shale with small sandstone strata	111	276
	Sandstone	44	320
	Sandstone and shale strata	20	340
	Shale	8	348
	Sandstone	15	363
	Shale, brown	40	403
Edmonton.	Sandstone	2	405
	Coal	8	413
	Shale, brown	95	508
	Sandstone	8	516
	Shale and sandstone strata	42	558
	Shale, grey (gas)	27	585
	Sandstone	5	590
	Shale, grey	150	740
	Coal	4	744
	Shale, dark	44	788
	Sandstone	6	794
	Shale, dark	31	825
	Coal	3	828
	Shale, light	10	838
	Shale, dark	50	888
	Shale, very light	6	894
	Shale, dark	6	900
	Shale, light	5	905
	Shale, dark	32	937
	Coal and shale strata	7	944

A second well was bored about half a mile east of the first, apparently at the same level, but does not seem to have the same measures as the lower part of the first well, that is, the coal seams are apparently not continuous.

41. *Wetaskiwin*—Continued.

Well No. 2. W. L. Crane, city engineer.
Drilled by Northwest Drilling Company, 1913.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Coal seams (two) in top measure	710	710
	Clay, blue	145	855
	Sand, grey	23	878
	Coal	2	880
Shale member below Edmonton formation.	Shale, black	70	950
	Sand, soft, grey	52	1,002
	Mud, shaly (little gas at 1,187 feet)	185	1,187
	Mud, shaly (gas at 1,216 feet)	29	1,216
Part of upper part of Belly River formation.	Sand (gas at 1,248 feet)	30	1,255
	Shale, broken, and sand	35	1,290
	Sand (gas at 1,347 feet)	82	1,372
	Slate, white	48	1,420
	Sand (gas at 1,443 feet)	45	1,465
	Slate, white	46	1,511

A third well was drilled near No. 1, the log of the lower part of this well is furnished by the city clerk and probably continues that of No. 1. The intervening members as given in well No. 2 seem to show a passing through a small thickness of shales and a second sandy member entered at 1,216 feet, giving a thickness of 336 feet for these shales to be added to well section No. 1. No. 3 then furnishes the remainder of the No. 1 section.

No. 3 gas well from 1,400 to 3,180 feet.
Driller's record.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Part of sandy upper member of Belly River formation.	Shale, grey, sandy, hard	70	1,470
	Shale, brown	30	1,500
	Shale, brown, with small sandy shells	30	1,530
	Shale, grey, sandy, brown and hard	10	1,540
	Shale, hard, grey	10	1,550
	Shale, hard, brown	5	1,555
	Sandstone, hard, grey	5	1,560
	Shale, hard, grey, sandy	80	1,640
	Sandstone, hard, grey	22	1,662
	Shale, hard, brown	59	1,720
	Shale, hard, grey, sandy; gas 20,000 feet at 1,740 feet	70	1,790
	Shale, hard, brown	40	1,830
	Sand, grey; water at 1,835 feet	20	1,850
	Shale, sandy; water at 1,860 feet	40	1,890
	Sandstone; water at 1,915 feet	25	1,915
	Shale	75	1,990
	Shale, grey	10	2,000
	Shale, sandy, grey: gas at 2,035 feet	120	2,120
Shale member Belly River	Shale, brown	60	2,180
	Shale, grey	75	2,255
	Shale, brown	689	2,944
Lower sands of Belly River	Sandstone, brown	81	3,025
	Shale, brown	25	3,050
	Shale, brown, and sandstone	50	3,100
	Shale, light brown, and sandstone	70	3,170
	Sandstone, grey	10	3,180

41. *Wetaskiwin*—Continued.

The section given in wells No. 1 and No. 3 may be considered as continuous, whereas well No. 2 gives the shale beds between the Edmonton and top of the Belly River. These may not be typical marine deposits, but are supposed to be at about the horizon of the Bearpaw. Putting well No. 2 between No. 1 and No. 3 we get a section of 403 feet for Paskapoo; 541 for Edmonton; 336 feet of shales at base of Edmonton; 840 feet sandy measures of upper part of the Belly River formation followed by 824 feet of shales probably marine member of Belly River, and 236 feet of the lower sandy member of the Belly River formation comparable with the Milk River sandstones.

403 feet	Paskapoo.	
541 "	Edmonton.	
336 "	Shales.	
840 "	Sandy measures.	Belly River formation.
824 "	Shale.	
236 "	Sandy measures.	
3,180 feet	Depth of well No. 3.	

42. *Camrose.*

Sec. 2, tp. 47, range 20, W. 4th mer.
Well bored for gas in the town.
Elevation: 2,427 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Edmonton.	Deposits, surface	10	10
	Clay, yellow	25	35
	Clay, blue	75	110
	Coal	5	115
	Shale, grey	20	135
	Shale, sandy	30	165
	Coal	1	166
	Shale, brown	89	255
	Coal		
	Shale, brown	22	277
	Shale, brown	118	395
	Coal, shale, some water	19	414
Probably Pierre shales.	Shale, brown	6	420
	Slate, grey	23	443
	Sandstone, grey	33	476
	Shale, grey	14	490
	Shale, brown	70	560
	Sandstone	11	571
	Shales, sandy, brown	69	640
	Slate, grey	20	660
	Slate, sandy	30	690
Probably reached the Belly River.	Slate, grey	10	700
	Slate, sandy (gas)	20	720
	Sandstone, grey, and sandy shale	163	883
	Slate, green	12	895
	Slate, sandy	65	960
	Shale, brown	5	965
	Sandstone	5	970
	Shale, grey, sandy	70	1,040
	Shale, brown	5	1,045
	Slate, sandy	97	1,142
	Shale, brown	38	1,180
	Slate, grey	20	1,200
	Shale, grey, sandy	35	1,235
	Gas obtained: 149,200 cu. ft. per day.		

43. *Tofield.*

Sec. 1, tp. 51, range 10, W. 4th mer.
Elevation: station, 2,205 feet.
Driller's record of town well No. 2.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Clay, blue	20	20
	Sand, grey, and water	40	60
	Sand, grey	15	75
	Shale, brown	45	120
	Shells and sand	15	135
	Shale, brown	65	200
	Sand, grey	12	212
	Shales, brown	58	270
	Sand, grey (gas at 273 feet)	10	280
Well starts near base of Edmonton.	Shale, brown	60	340
	Sand, grey, gas at 390 feet; water 490 feet	175	515
	Shale, brown	95	610
	Sand, grey	5	615
	Coal	3	618
	Sand, grey	7	625
	Clay, blue	225	850
	Shells, lime	10	860
	Shale, blue	100	960
	Sand (gas)	40	1,000
	Shale, brown	20	1,020
	Slate, blue	37	1,057
	Water and a little gas at 1,065 feet.		
	Slate, blue	68	1,125
	Sand, dark	10	1,135
	Clay, blue	12	1,147
	Sand, dark	6	1,153
	Clay, blue	50	1,203

44. *East Edmonton.*

Sec. 30, tp. 52, range 23, W. 4th mer.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Soil	30	30
	Sand	10	40
	Clay	30	70
	Sand and marl	20	90
	Sand and boulders	30	120
	Clay marl and boulders	5	125
Edmonton	Clay and shale	20	145
	Coal	6	151
	Shale, brown	36	187
	Clay	8	195
	Shell and shale	10	205
	Shale, soft, brown; clay	45	250
	Shell, hard, gypsum and sand	40	290
	Shale and *coal*	5	295
	Shale (some gas)	20	315
	Shell, sand and clay	25	340
	Gypsum and sand	30	370
	Shale, soft, brown	10	380
	Shale, and clay	15	395
	Shell, sand and shale	55	450
	Shale, brown	42	492
	Limestone shell	5	497
Probably part of this division is marine representing the Pierre.	Shale, brown	50	547
	Limestone shell	3	550
	Clay and sand	23	573
	Shale, brown	7	580
	Gypsum and sand	10	590
	Shale, yellow	5	595
	Shale, brown	15	610
	Clay and shale (gas flow)	28	638
	Slate and limestone shell	2	640
	Shale, blue	16	656
	Shale, yellow	4	660
	Shale, blue	12	672
	Gypsum and sand	11	683
	Clay and shell (gas flow)	12	695
	Shell, yellow	5	700
	Shale, blue	66	766
	Clay, brown, and blue shale	16	782
	Shale, blue	13	795
	Shell, brown	1	796
	Shale, blue	12	808
	Shale, blue, and sand	12	820
	Shell, brown	2	822
	Sand (gas flow)	8	830
	Shale, dark	5	835
	Shell, yellow	2	837
May be Belly River beds	Shale, dark	18	855
	Clay, blue, and nodules	5	860
	Shales, blue and brown	70	930
	Clay and shale	10	940
	Shale, light-coloured, at bottom.		

Samples were from a rotary drill.

45. *Edmonton.*

Well No. 2 on north side of Jasper avenue.
The Northwest Gas and Oil Company, Ltd.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Edmonton formation.	Through alluvial soil for 10 feet, then sand and gravel to 35 feet, and soft clay to a depth of 50 feet	50	50
	Clay, soft, and shale continue	40	90
	Coal, 12-inch seam. Slate formation. 5 feet of gravel	35	125
	Slate and shale	25	150
	Slate and shale continue to 215 feet	65	215
	Coal, 8 feet thick	8	223
	Slate, black, and shale from 223 to 260 feet	37	260
	Coal, hard, 9-foot seam	9	269
	Sand, grey, and shale continuing for 30 feet	30	299
Probably upper Pierre.	Slate rock, black, and clay in alternate layers to 400 feet	101	400
	Shale, black, grey, and sand	35	435
	Sand, brown, with layers of black slate for 30 feet	30	465
	Slate, black, and shale continue	35	500
	Slate, black, and shale of varying degrees of hardness	60	560
	Formation is changed for soft grey and followed by seam of grey slate 10 feet thick. Grey sand and slate alternating to 610 feet.	50	610
	Gas, small flow, was struck in a dark, soft, slate formation which continued to 700 feet	90	700
	Shale, dark	90	790
	Formation continues the same	60	850
	Formation continues dark slate and shale. A small flow of brackish water	60	910
	Gas, small flow, from 910 to 940 feet	30	940
	Shale, very soft, dark, to 1,000 feet	60	1,000
	Clay, soft, or shale, alternating with thin layers of rock	80	1,080
Belly River.	Rock, hard, to 1,118 feet	38	1,118
	Rock, soft, dark, and shale to 1,160 feet	42	1,160
	Sand rock, dark grey, of the nature of a boulder bed	29	1,189
	Bed, boulder, apparently ended, and a soft, blue shale was entered	7	1,196
	Boulder bed (second), of 5 feet, followed by hard, blue sand rock for about 12 feet	17	1,213
	Shale, soft, from 1,208 to 1,243 feet	30	1,243
	Sand, dark grey, 5 feet, yielding a small quantity of oil, salt-water, and gas. Soft, grey shale, with layers of dark grey sand continued to 1,306 feet	63	1,306
	From 1,306 to 1,358 feet very little change in the formation	52	1,358
	Shale, dark, with frequent layers of coal and sand down to 1,412 feet	54	1,412
	This well was continued to a depth of about 1,800 feet, but the log is not available	388	1,800

46. *Morinville.*

SE. ¼ sec. 13, tp. 56, range 25, W. 4th mer.
Well of American-Canadian Oil Company, Ltd.
Elevation: approximately 2,300 feet.
Driller's notes extracted from paper by Huntley in Trans. Inst. Min. Eng., vol. LII, 1916, p. 347.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Clay and boulders. Surface drift	250	250
	Sand rock	10	260
	Shale, blue and brown, thin layers of sandstone	180	440
	Sand rock with gas	15	455
	Shale, blue and brown, thin layers of sandstone	945	1,410
	Shale, dark blue, with thick oil seepage	5	1,415
	Shale, blue, dark blue to light blue and green (At 1,475 feet small flow of oil, 1,498 feet soft sandstone with some oil.)	1,035	2,450
	Shell, ironstone, hard	6	2,456
	Shale, blue and grey, with gas	444	2,900
	Gravel (coarse sand probably), salt water	2	2,902
	Shale, greenish (like dobe shale)	38	2,940
	Sand rock with heavy oil, flow of gas underneath	112	3,052
	Shell, hard, with iron	10	3,062
	Shale, greenish (dobe)	38	3,100
	Shale, blue, with thin layers of sandstone	100	3,200
	Shale, greenish, very sticky	60	3,260
	Shell, ironstone, hard	2	3,262
	Shale, blue, sandy, with oil seepages	48	3,310
	Shale, blue, sandy, with hard lime shells	30	3,340

The information that this log gives is very general and the divisions between the formations are not shown. It is known that the well started below the Morinville coal seam and, therefore, near the bottom of the Edmonton. We may, therefore, assume that probably the sand rock at 465 feet is in the Pierre and is equivalent to that at Bulwark north of Coronation. The Belly River sandy beds with shales are not clearly shown, but probably were passed in the drilling before 2,450-foot depth was reached. The blue grey shale from 2,456 to 2,900 feet is probably Colorado and the sands below 2,940 feet may be equivalent to those of the Pelican and Grand Rapids sections of the Athabaska river. The bottom of the well may thus be in the Clearwater shale.

47. *Athabaska.*

Sec. 21, tp. 66, range 22, W. 4th mer.
Well drilled by Geological Survey at Athabaska Landing, 1895.
Elevation: River-level, 1,550 feet; railway station, 1,690 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Drift	14	14
	Shale, grey, soft, and caving badly (At 23 feet, 136 feet, and 245 feet hard streaks met. Below the hard streak at 245 feet a strong flow of gas.)	231	245
	Shale, soft (A heavy flow of gas at 334 feet, a hard streak at 338 feet.)	155	400

47. *Athabaska*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Upper La Biche shales probably lower Pierre.	Shale, slightly harder.....	25	425
	(At 425 feet a hard stratum about 1 foot thick)		
	Shale, grey.....	75	500
	Shale, darker, soft, caving badly.....	50	550
	Shale with streaks of sand rock 1 to 2 feet thick.....	30	580
Lower La Biche shales.	Shale, dark, very soft.....	245	825
	(At 780 feet salt water was struck, and a strong flow of gas.)		
	Shale, harder and bluer.....	75	900
	Shale, soft, dark.....	115	1,015
	Shale, hard, light.....	22	1,037
	Shale, dark.....	53	1,090
Pelican sandstone.	Sandstone, carrying water.....	40	1,130
Pelican shales.	Shale, dark, caving badly.....	40	1,170
	Shale, dark, with layers of sandstone.....	37	1,207
	Shale, dull, reddish, and sandstone.....	26	1,233
	Shale, dark, soft.....	4	1,237
	Shale, light grey, very hard.....	5	1,242
	Shale, light grey, soft.....	5	1,247
	Shale, dark, soft.....	8	1,255
Grand Rapids sandstone.	Sandstone, very hard.....	5	1,260
	Shale, dark, soft.....	25	1,285
	Sandstone, hard.....	25	1,310
	Shale, dull reddish, and sandstone, soft.....	13	1,323
	Shale, reddish.....	15	1,338
	Sandstone and dark shale.....	12	1,350
	Shale, dull reddish, and a little sandstone....	41	1,391
	Sandstone with layers of dark shale.....	44	1,435
	Sandstone, hard, with soft streaks.....	3	1,448
	Sandstone and dark shale.....	13	1,461
	Shale, dark (thin streaks of lignite).....	30	1,491
Clearwater shales.	Shale, light, hard.....	40	1,531
	Shale, not so hard.....	9	1,540
	No record.....	26	1,566
	Sandstone, hard.....	10	1,576
	Shale, hard.....	25	1,601
	Shale, hard, with soft streaks.....	12	1,613
	Shale, hard.....	13	1,626
	Ironstone boulder, very hard.....	7	1,633
	Shale, hard (a little gas about 1,650 feet)....	49	1,682
	Shale, hard and soft, alternating.....	7	1,689
	Shale and sandstone alternating.....	33	1,722
	Shale with a little sandstone.....	9	1,731
	Shale, soft and dark.....	5	1,736
	Sand rock, hard.....	11	1,747
	Shale.....	5	1,752
	Shale and sandstone.....	7	1,759
	Shale.....	4	1,763
	Sandstone, supposed, hard.....	4	1,767
	Shale, soft.....	3	1,770

An upward continuation of this section is given by Dr. G. M. Dawson, Ann. Rept., Geol. Surv., vol. XII, p. 14A.

Height above bore-hole. Feet.		Feet.
180	Yellowish sandstone. Thin beds with some ironstone.....	15
165	Shales, grey, probably with some thin sandstone layers, not well exposed.....	165
		180

48, *Pelican No. 1.*

Pelican Oil and Gas Company.
Elevation: approximately 1,300 feet.
Driller's log extract from Trans. Am. Min. Eng., vol. LII, p. 346.
This well is started at higher level than the government well.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Pelican shale.	Shale, blue and yellow	66	66
	Shale, white and grey	16	82
	Shale, blue	118	200
Grand Rapids sandstone.	Shale, blue and brown	35	235
	Shale, brown	50	285
	Shale, grey, brown	46	331
	Sand rock (hard)	21	352
	Shale	13	365
	Sand rock	60	425
Clearwater shales.	Shale	82	507
	Shell, brown (hard)	2½	509½
	Shale, grey	28½	538
	Shell	2	540
	Sandstone	6	546
	Shale	29	575
	Shell, hard	6	581
	Shale, grey, streaks of sandstone. (Strong flow of gas at bottom.)	44	625
	Shale, grey, with streaks of sand	19	644
	Shale, grey, with gas	9	653
	Shale, grey, soft	13	666
	Sand rock	5	671
	Shale, grey	17	688
	Shell, hard, brown	1	689
	Shale, dark grey	51	740
	Shell, hard	1	741
	Shale, dark grey	25	766
	Shell, hard	1	767
	Shale, dark grey	76½	843½
McMurray sandstone.	Shale, sandy	38½	882
	Rock, coarse, mixed with heavy oil	5	887
	Shale and sand	11	898
Devonian.	Rock, hard	5	903
	Lime carrying oil	94	997
	Limestone	54	1,051
	Shell, hard, flinty	2½	1,053½
	Limestone	4½	1,158
	Lime shell, hard	1	1,159
	Limestone	33	1,192
	Shell, hard (gypsum)	5	1,197
	Shale, blue, and gypsum	96	1,293
	Lime shell, hard	3	1,296
	Rock, lime	232	1,538
	Lime, shale, and lime rock	22	1,560
	Shale, grey, and lime (gas)	140	1,700
	Limestone	84	1,784
	Shell, hard	6	1,790
	Rock, lime, shale streaks	85	1,875
	Shell, hard	4	1,879
	Limestone, layers, and shale, strong flow of gas	161	2,040
	Limestone and shale interstratified	29	2,069

49. *Pelican Rapids.*

About sec. 6, tp. 79, range 17, W. 4th mer.
Well drilled by Geological Survey at mouth of Pelican river.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Sand and gravel	86	86
Pelican shale.	Shale, very soft, dark bluish	15	101
	Sandstone, soft	4	105
	Shale, very soft, dark bluish. At 185 feet slightly saline water	80	185
	Shale, rather hard, reddish brown	40	225
	Sandstone. At 225 feet water	9	234
	Sandstone and brown shale	11	245
	Shale, hard, grey. At 253 feet more water and gas	8	253
	Shale, light greenish-grey	27	280
	Shale, soft, greenish-grey, cement-like	10	290
	Shale, brown, with strata of grey shale	18	308
Grand Rapids sandstones.	Shale, brown	2	310
	Sandstone, hard. More gas and water	1	311
	Shale, brown, and sandstone in alternate strata	17	328
	Sandstone	12	340
	Shale, brown	13	353
	Sand rock, hard, with layers of softer rock. (At 355 feet struck maltha and gas.)	12	365
	Sandstone, rather hard	45	410
	Shale, brown	17	427
	Shale, hard, brown	23	450
	Sandstone. More gas and water	15	465
	Shale, grey	61	526
Clearwater shales.	Ironstone	6	532
	Shale, grey	21	553
	Sandstone	3	556
	Very hard, probably ironstone	2	558
	Sandstone, very hard	5	563
	Shale, brown	10	573
	Shale, grey, streaks of sandstone	17	590
	Shale, grey, brown shale and sandstone in alternating strata; the cuttings show traces of maltha	30	620
	Shale, grey, strong flow of gas at 625 feet; considerable maltha coming away with the water	5	625
	Sandstone, very hard	18	643
	Shale, soft, grey	5	648
Clearwater shales.	Sandstone, hard	4	652
	Shale, soft, grey, sandy	13	665
	Ironstone	10	675
	Shale, soft, grey	9	684
	Sandstone, hard	1	685
	Shale, soft, dark grey	18	703
	Sandstone, hard	10	713
	Shale, soft, grey, sandy	5	718
	Sandstone, hard	5	723
	Sandstone	10	733
	Shale, soft, grey	10	743
	Shale, soft, grey, with streaks of soft sandstone. Strong flow of gas at 750 feet. A heavy oil mixed all through the sandstone and shale	7	750

40, *Pelican Rapids*—Continued.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Tar sands (McMurray sands).	Shale, soft, dark grey, and soft sandstone. Heavy oil throughout. At 773 feet a heavier flow of gas	31	781
	Alternate strata of soft grey shale and soft sandstone. Increased quantities of heavy petroleum. Gas increasing in volume	19	800
	Same as foregoing; At 820 feet, a tremendous flow of gas of which the roar could be heard 3 miles or more	20	820
	Sandstone, soft. Hard streak, and light flow of gas at 830 feet	10	830
	Sandstone, soft	6	836
	[1]Iron pyrites nodules embedded in cement-like sandstone. Very strong flow of gas	1	837

Dr. Dawson[2] gives the following section from this well:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Sand and gravel (surface deposits)	86	86
	Shales, dark, bluish-black, soft, with some sandstone in upper part. *Pelican shales*	99	185
	Sands, greyish, and sandstones and brownish and greyish shales, Grand Rapids sandstones	280	465
	Shales, greyish and brownish, alternating with thin beds of hard sandstone and ironstone. *Clearwater shales*	285	750
	Sands and clays often saturated with heavy oils and tar. *Tar sands*	87 or more	837

[1]Geol. Surv., Can., Sum. Repts., 1897, 1898.
[2]Geol. Surv., Can., vol. X, p. 19A.

50. *House River.*

Well No. 1 of the Great Northern Asphalt and Oil Company.
Elevation: approximately 1,260 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
Grand Rapids sandstone.	Soil	16	16
	Sandstone	8	24
	Clay	58	82
	Sandstone (water and gas)	3	85
	Clay	5	90
	Sandstone, dark grey	50	140
	Clay, sandy	10	150
	Clay, sticky	10	160
	Sandstone	5	165
	Clay, sandy	4	169
	Sandstone, dark grey	6	175
	Sandstone, hard, streak	2	177
	Sandstone, dark grey	23	200
Clearwater shales.	Clay	8	208
	Sand	16	224
	Shale, blue	6	230
	Sand, coarse	10	240
	Clay, blue	50	290
	Sandstone, grey, hard, heavy gas and some oil	2	292
	Shale, blue	1	293
	Sandstone	2	295

Rig burned by gas.

51. *McMurray.*

Sec. 16, tp. 89, range 9, W. 4th mer.
Well No. 2, [1]Great Northern Exploration Company.
Elevation: about 817 feet.

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Soil	17	17
Devonian.	Limestone	60	77
	Shale	15	92
	Lime	60	152
	Shale	40	192
	Shale, soft	5	197
	Lime	40	237
	Shale	5	242
	Lime	120	362
	Shale	20	382
	Lime	80	462
	Shale	40	502
	Lime	60	562
	Shale	30	592
	Lime	12	604
	Salt (salt water), probably gypsum	100	704
	Limestone	75	779
	Salt (salt water), probably gypsum	90	869
	Lime	130	999
	Shale	60	1,059
Athabaska sandstone	Sandstone, brown	80	1,139
Probably Archæan	Rock, red, hard, streaked	266	1,405

[1]Huntley, L. G., Inst. Am. Min. Eng., vol. LII, p. 347.

52. *Peace River.*

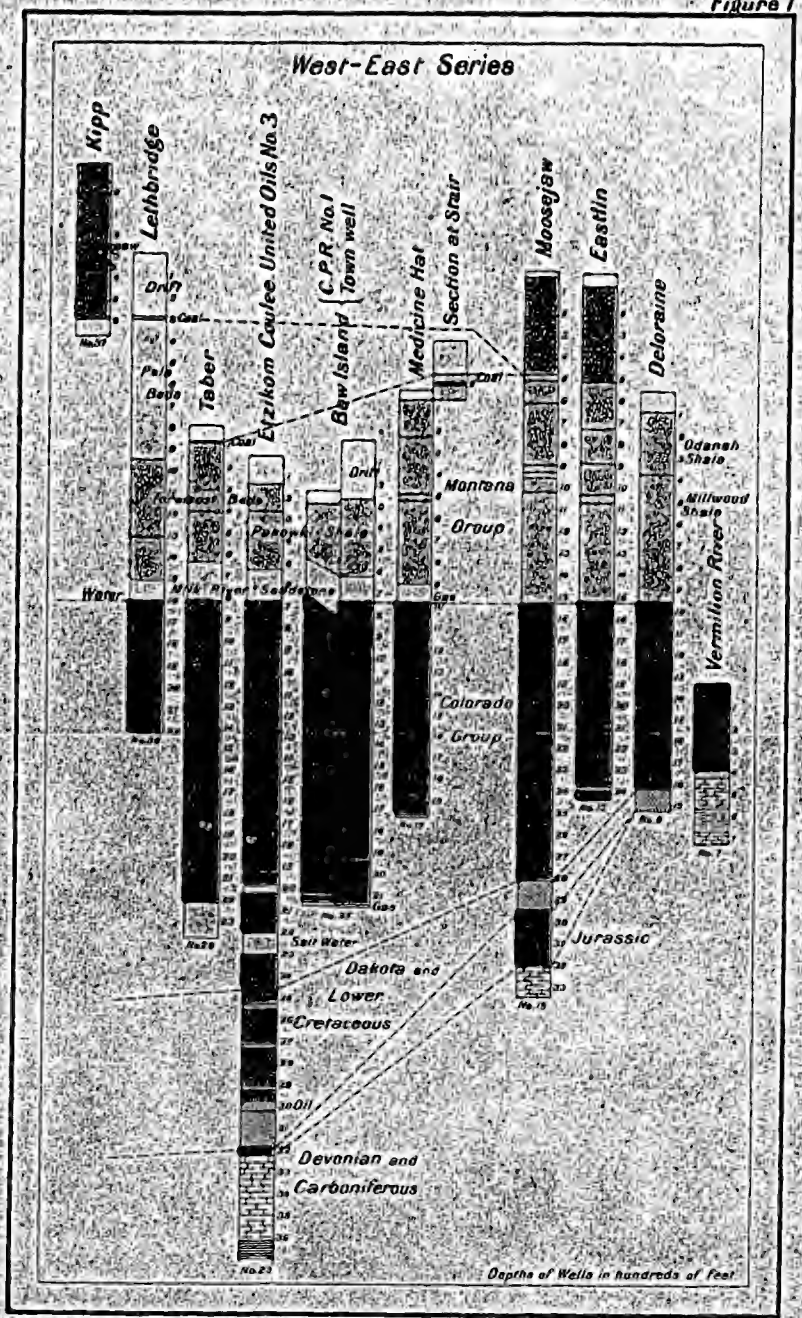
Probably in tp. 84, range 21, W. 5th mer.
Elevation: about 1,000 feet.
Driller's record:

Probable formation.	Material.	Thickness in feet.	Depth from surface in feet.
	Gravel, river, and stones	32	32
	Gravel, river, and stones	32	64
	Sand, fine	27	91
	Sand and blue clay at 93 feet	12	103
	Clay, blue, and lime rock at 126 feet	33	136
	Lime rock	27	163
	Shale, blue, sandy	16	179
	Shale, blue, sandy, with thin bands of sand rock about every 8 to 10 feet; at 220 feet struck small flow of gas and salt water	98	277
	Shale, blue	67	344
	Rock, sand, grey	23	367
	Shale, blue	48	415
Peace River sandstone.	Shale rock, grey; struck good flow of gas, making flame about 4 feet high; gas has distinct odour of petroleum	16	431
	Shale, blue	64	495
	Sand rock, another flow of gas with strong petroleum odour	25	520
	Shale, blue	25	545
	Slate	10	555
	Shale, blue	52	607
	Sand rock	14	621
	Shale, brown	26	647
	Lime rock, grey	44	691
	Shale, blue	32	723
	Lime rock, grey, band of	11	734
	Shale, blue; at 850 feet very strong smell of heavy asphalt oil	123	857
Loon River shale.	Rock, lime, grey; good showing of heavy asphalt oil	13	870
	Sand rock becoming very hard at 880 feet; oil would probably give 5 barrels per day if pump put in	13	883
	Rock, lime, grey, still very hard; oil showing not any stronger as oil sand has been passed through; small flow of gas at 910 to 915 feet	44	927
	Shale, blue	53	980
	Sand rock with good showing of oil of better quality than last.		
	Sand rock; more oil being encountered	12	992
	Sand rock	53	1,045
	Shale, blue	12	1,057
Probably part of Tar sands	Sand rock cemented with lime, small amount of oil showing in this formation	26	1,083
	Shale, brown, saturated with oil	2	1,085
	Rock, lime, grey	8	1,093
	Rock, lime, grey, and very light blue shale	7	1,100
	Shale, blue	7	1,107

The well was started on the river in the Peace River sandstone of McConnells section. The sands at the bottom of the well should represent the base of the Loon River shales, but as no sands were observed on Peace river these may be equivalent to the tar sands of the Athabaska section.

INDEX.

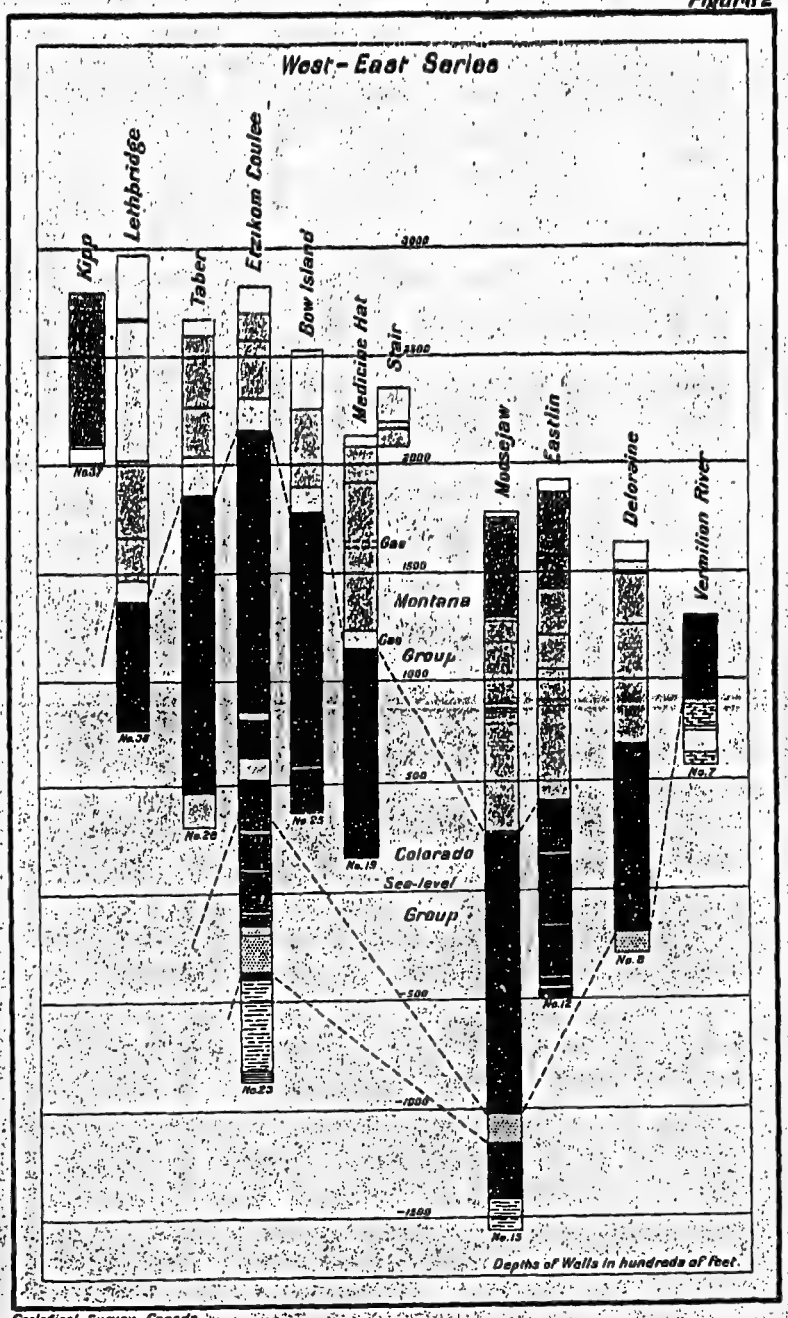
Figure I



Geological Survey, Canada.

Well sections, arranged in west-east order, showing correlation of the geological formations.

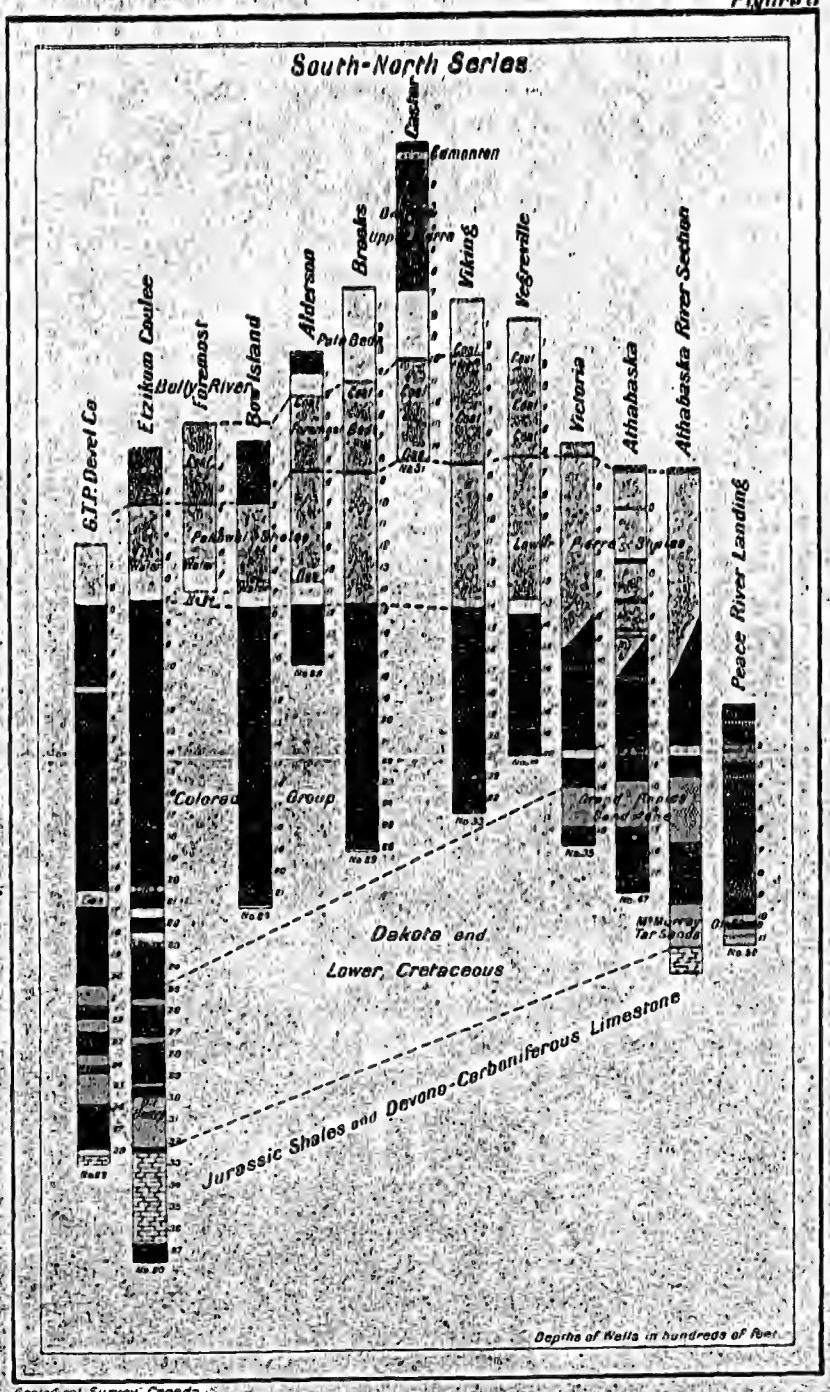
Figure 2



Geological Survey, Canada.

Well sections, arranged in west-east order, in relation to sea-level.

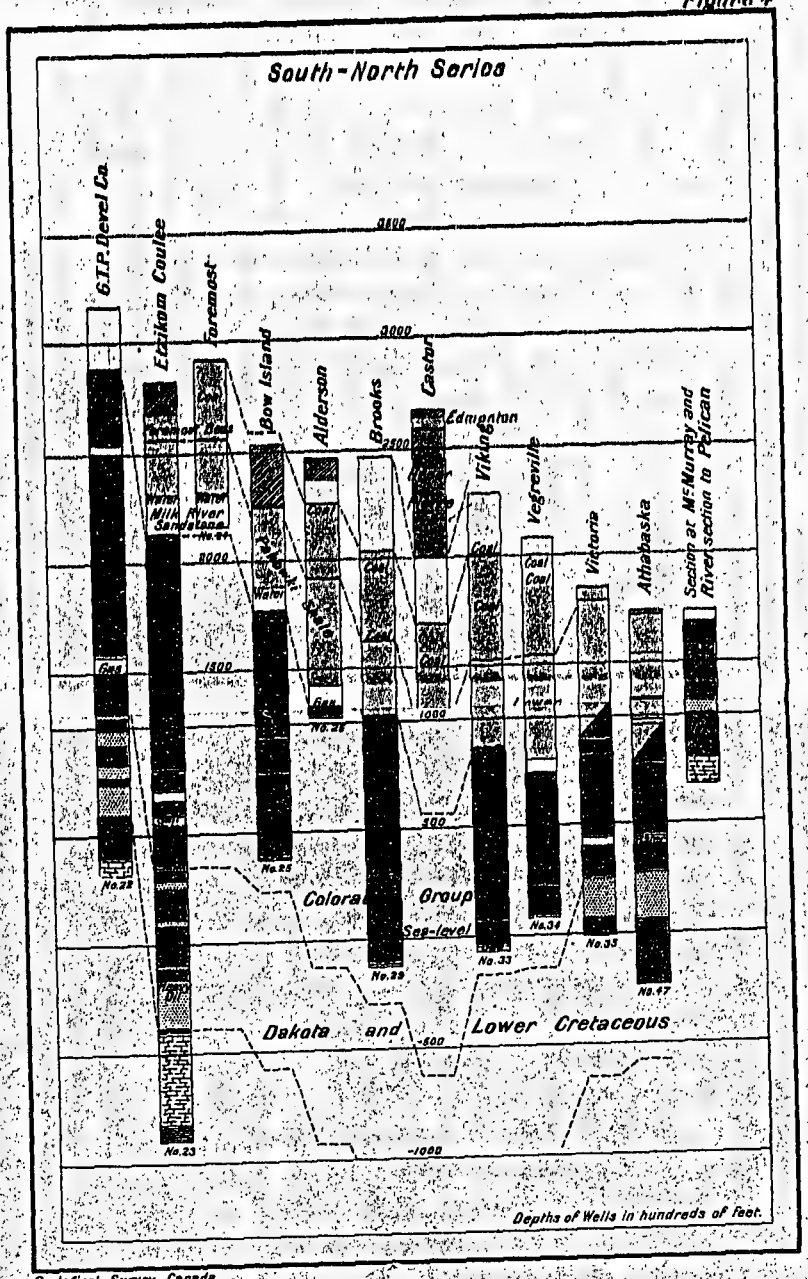
Figure 3



Geological Survey, Canada.

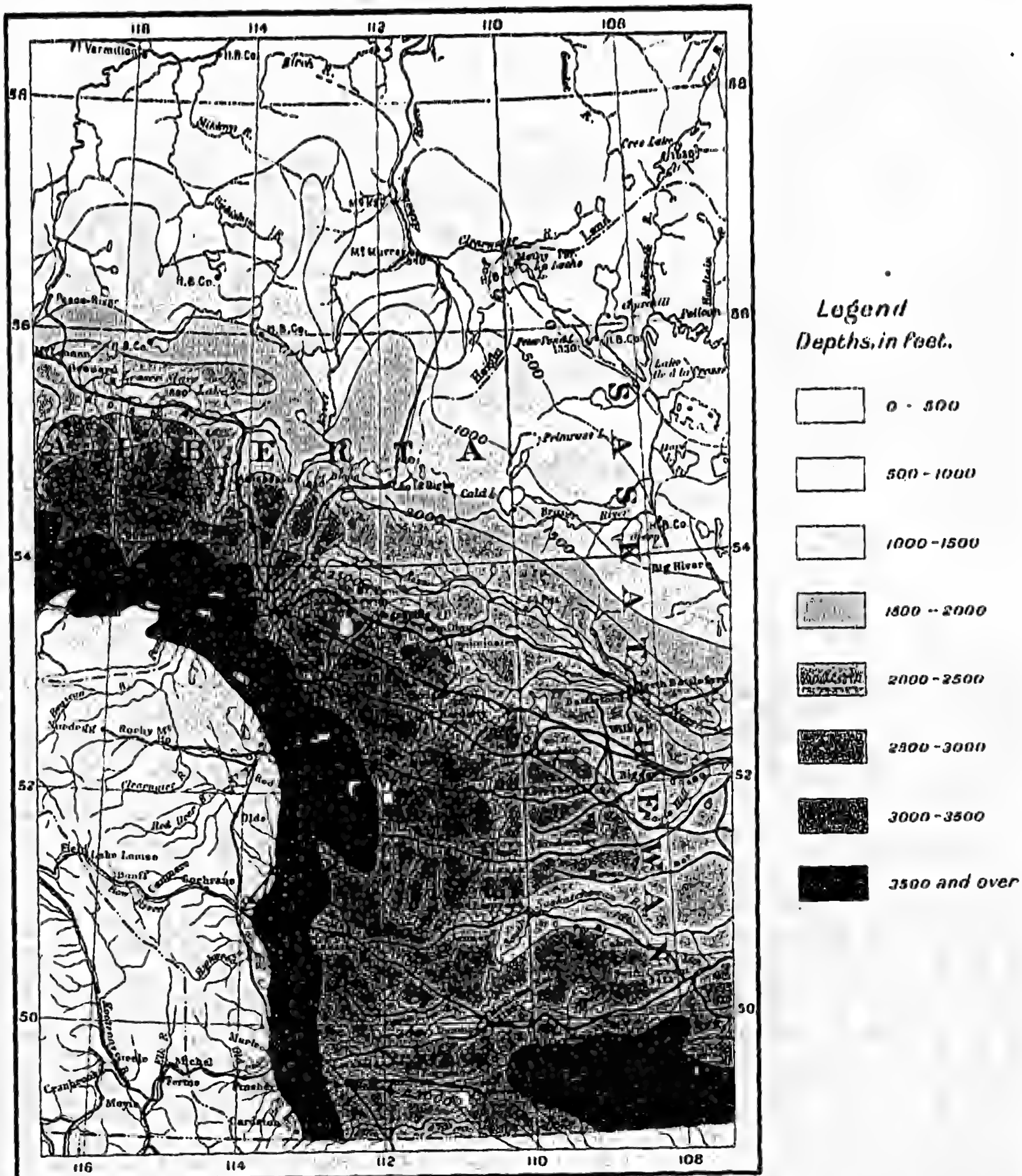
Well sections, arranged in south-north order, showing correlation of the geological formations.

Figure 4



Geological Survey, Canada.

Well sections, arranged in south-north order, in relation to sea-level.



Geological Survey, Canada

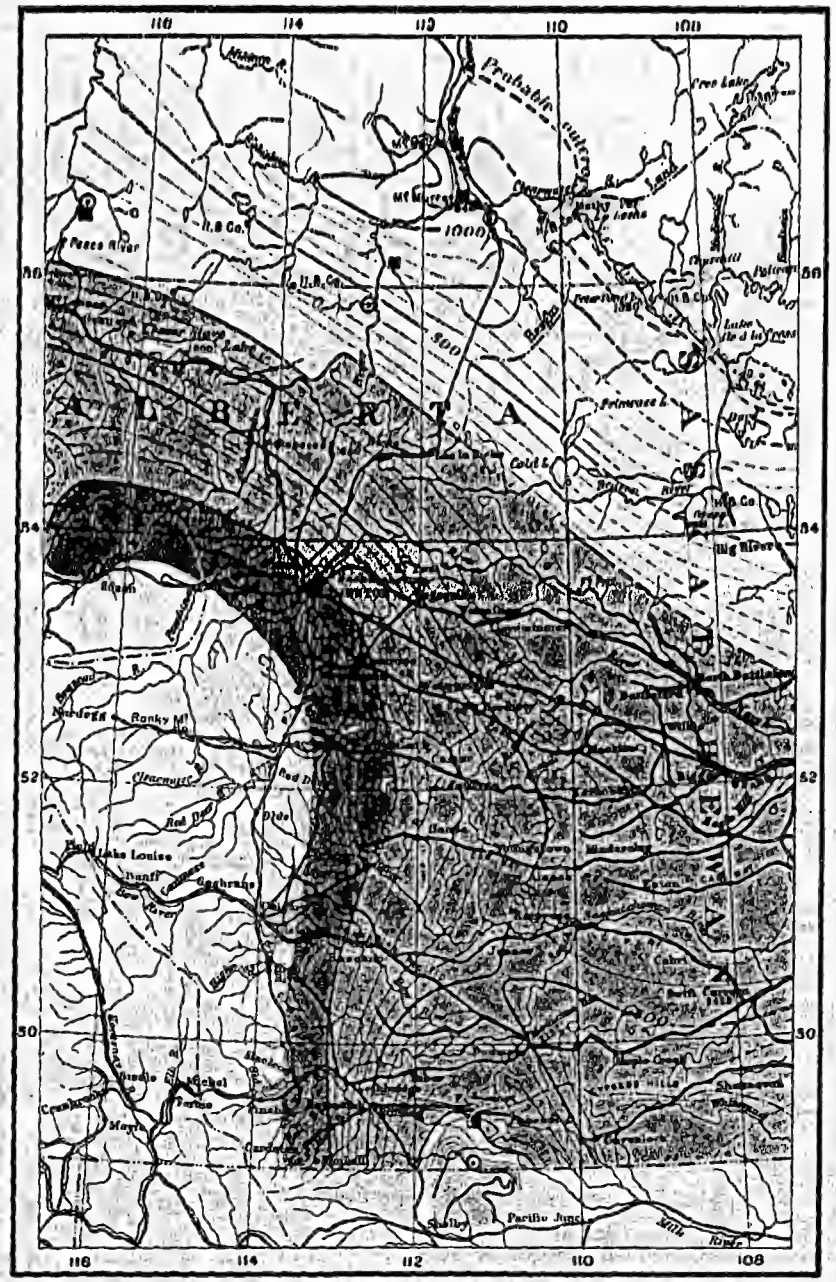
Pub. No 1782

Diagram showing depths from surface to Oil and Gas Sand

Scale of Miles

100 0 100

To accompany Memoir by D B Dowling



Geological Survey, Canada

Pub. No 1781

Structure contours showing Oil and Gas Sand at base of Cretaceous

Scale of Miles

100 0 100

To accompany Memoir by D.B Dowling.

Legend

Elevations, in feet, above sea-level

- 2000 - 3000
- 1000 - 2000
- 0 - 1000
- 500 — Structure contours (above sea-level)

Depths, in feet, below sea-level

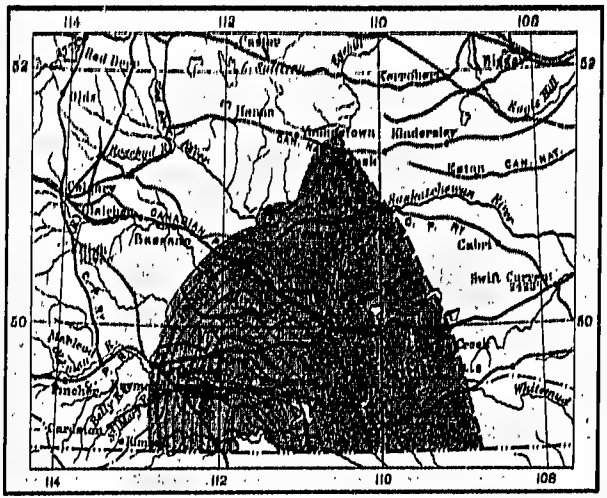
- 0 - 1000
- 1000 and over
- 500 — Structure contours (below sea-level)
- Large gas flow
- Thick oil or tar sand

Geological Survey, Canada.

Pub. No 1780

Sketch of basin occupied by Upper Cretaceous sediments.
(The United States portion is adapted from maps by Bailey Willis and L. S. Huntley)

To accompany Memoir by D. B. Dowling



Geological Survey, Canada. Pub. No 1778

Structure contours showing Medicine Hat Gas Horizon

Scale of Miles

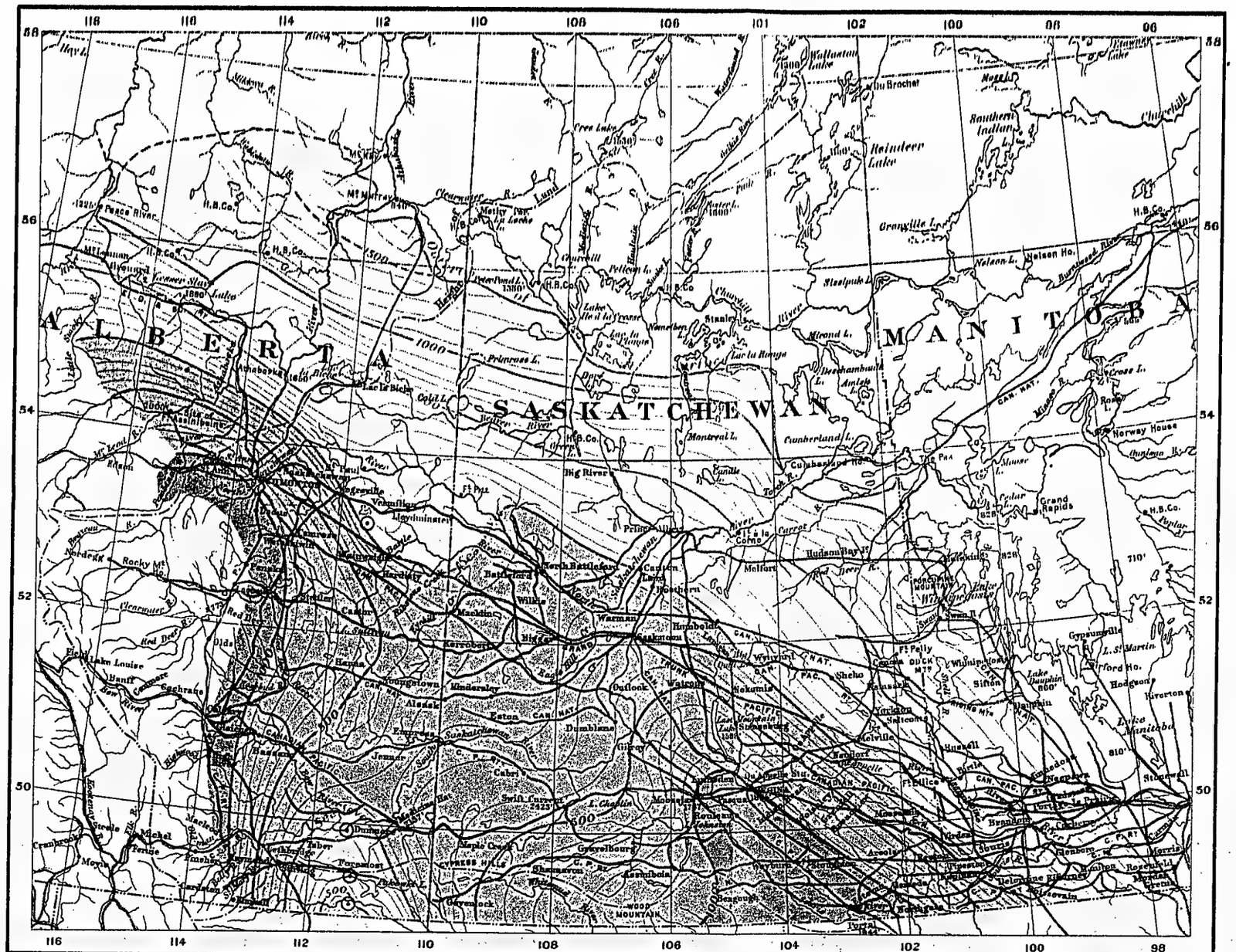
100 0 100

To accompany Memoir by D. B. Dowling.

Legend

Elevations, in feet, above sea-level

- 100 — Structure contours (above sea-level)
- Small gas flow
- Large gas flow
- Water-bearing sands
- Gas-bearing sands



Geological Survey, Canada.

Pub. Nº 1779

Structure contours showing Gas Horizon near base of Colorado Group.

To accompany Memoir by D. B. Dowling.

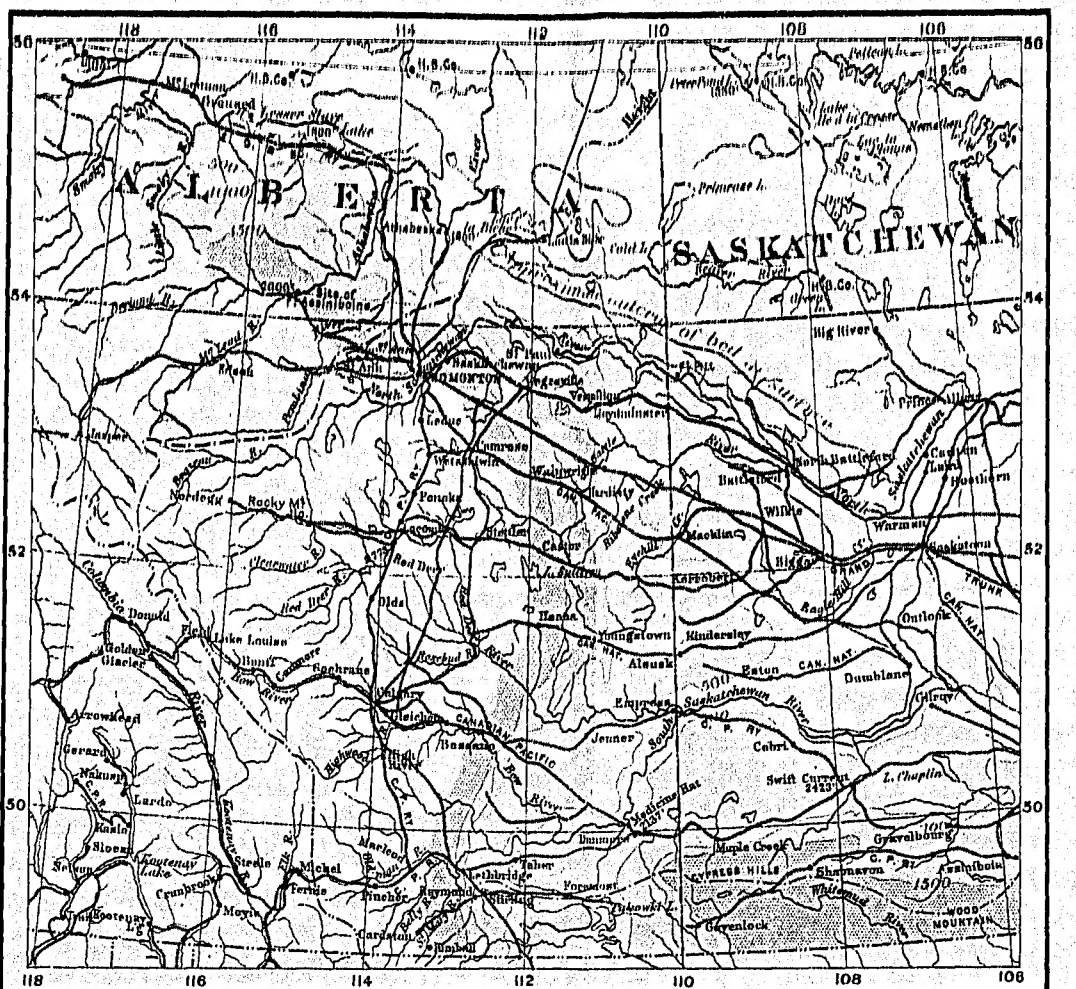
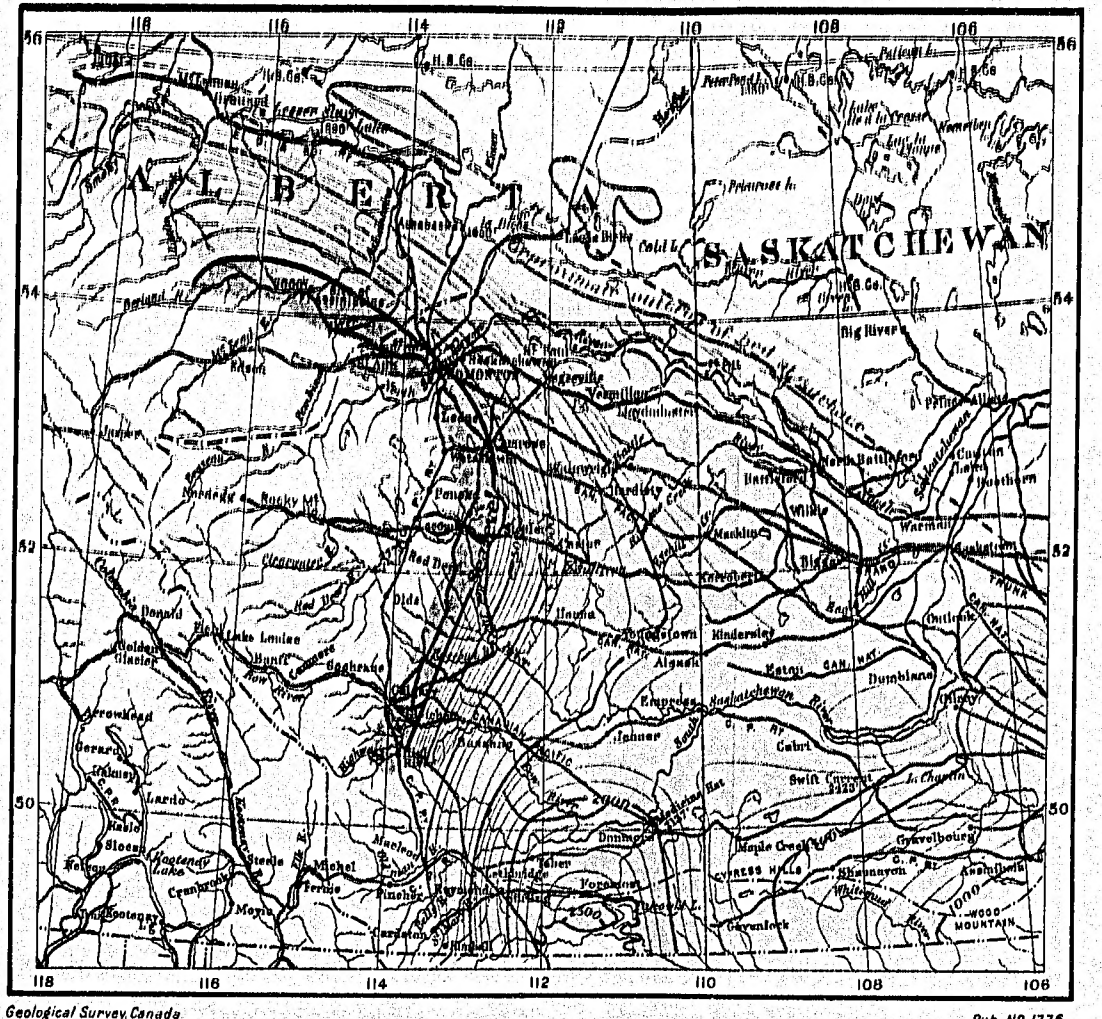


Diagram showing depths from surface to top of Lower Pierre shale

To accompany Memoir by D. B. Dowling.



Geological Survey, Canada

Pub. Nº 1776

Structure contours showing top of Lower Pierre shale

To accompany Memoir by D.B.Dowling.

Scale of Miles

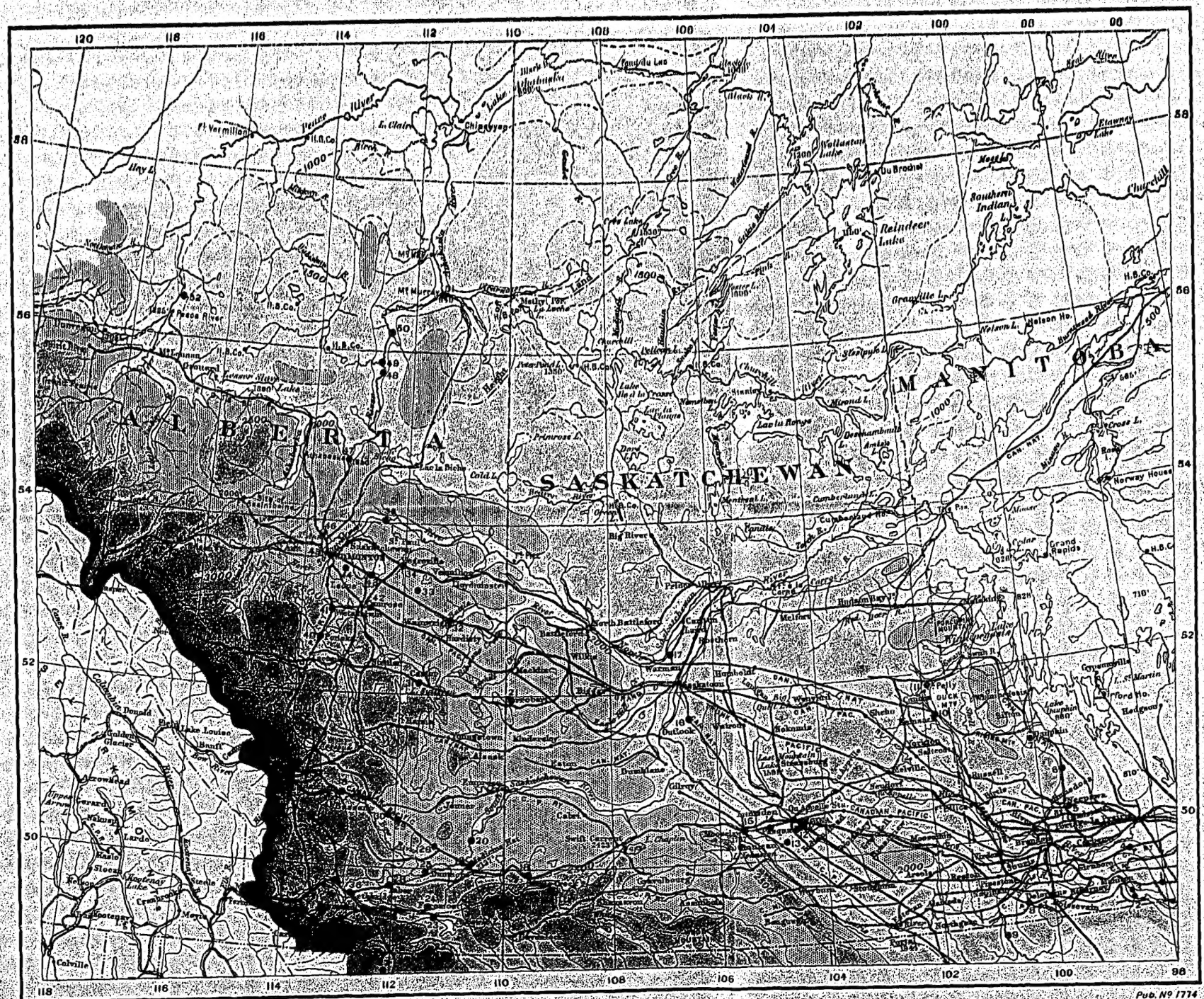
100 0 100

Geological Survey, Canada

Pub. No. 1775

Structure contours showing Top of Belly River sands

To accompany Memoir by D.B. Dowling.



Relief map of the prairie provinces